Saimaa University of Applied Sciences
Technology, Lappeenranta
Double Degree Programme in Civil and Construction Engineering
Civil and Construction Engineering

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HYDRO ISOLATION OF HISTORICAL BUILDINGS

Bachelor’s Thesis 2015

ABSTRACT
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Hydro isolation of historical buildings, 94 pages, 1 appendix
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The purpose of the thesis was collecting information about hydro isolation of historical buildings. In addition, task was the studying of necessity of waterproofing reconstruction, variants and methods of hydro isolation recovering by contemporary materials.

In the theoretical part of the study the main issues were the questions of historical buildings waterproofing, in interaction with soil condition. The object of the study is hydro isolation of the historical buildings, which are situated in the most complicated conditions in Saint-Petersburg. Information for the thesis was taken from special and technical literature, normative acts, and the projects, which are developed and implemented in reality in Saint-Petersburg by one of the leading companies of Saint-Petersburg LLC “Geoizol”.

As a result of this thesis, was approved effectivity of the buildings waterproofing, which was used 100-300 years ago. Historical types of waterproofing are effective, but laborious and non-industrial. In a result of this thesis the necessity of modern materials usage for solving the complicated waterproofing issues of long existing buildings is approved on the examples of the real projects. To protect the cultural heritage it is necessary to further develop the materials and technologies for providing the preservation of unique buildings, created 200-300 years ago.

Keywords: Hydro Isolation, Waterproofing, Waterproofing Materials, Historical Buildings, Saint-Petersburg

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1 INTRODUCTION

A building is a system, which consists of a few separate interconnected load bearing and enclosing structures, which form a closed ground volume, in which creates certain materially organized area for working, living and resting. The quality of the environment is determined by the physical parameters, which consist of: temperature, humidity, dust and gas content in the air, type of noise, light conditions, sound noise level, spectacular perceptions. All buildings are divided into three categories: civil, industrial and agricultural. Special interest is the historical buildings – the buildings, which are exploited for a very long time (100-300 years and more) and have historical-cultural value for the state.

Buildings are built and exploited in a certain area with specific natural-climatic and soil conditions. The subject of the thesis is the historical buildings of Saint-Petersburg.

Natural climatic conditions, as well as the soil conditions of the Russian Federation are a tremendous variety. It is not possible to consider all natural climatic and soil conditions of the Russian Federation in the thesis, because of this the topic will be the natural climatic conditions of Saint - Petersburg. Saint-Petersburg is situated on the Neva river banks, very close to the Baltic Sea on the plain territory. The maximum groundwater level is in average 1-3 meters under the zero-ground level. Because of this every building needs to have the water barriers.

Waterproofing solution of the historical buildings with age from 100 to 300 years is the subject of this thesis. The technical literature contains a small amount of information about creation and problems of waterproofing of the historical buildings. The thesis concentrated on the materials, which are widely available, and the surveying materials of the historical building made by LLC “Geoizol” St. Petersburg from 2008 to 2015.

LLC “Geoizol” in Saint-Petersburg – is the leading specialized company, which performs during the last 20 years the following range of activity:

- Installation of the pile foundations

– Installation of the anchors and micro piles
– Installation of the underground basements by method “wall in ground”
– Installation of the anti-filtration screens by method of jetting cementation “Jet Grouting”
– Complex of injection activities
– Geotechnical and hydro technical works
– Waterproofing works
– Road-construction works
– Test of the piles, anchors and grounds
– Building and structures surveying

Specialists of LLC “Geoizol” develop and introduce new technologies, including the area of historical buildings waterproofing. Information presented in the thesis is authentic, presenting technical decisions successfully implemented in the real life.

2 FEATURES OF BUILDING PRESERVATION

In the Russian Federation, buildings preservation is provided by quite a big amount of legislation acts: Federal Laws, SNIPs, GOSTs, SPs (building codes), TSN (territorial building codes), DBC (Departmental building codes) and hundreds of other obligatory documents, for example:

1. In the Russian Federation there exists a Federal Law “Technical Regulations on the safety of the buildings». It was approved by the state Duma in the December 23, 2009. Here are some positions from the law:

    - Article 3. Scope of this Federal Law

    Paragraph 6. The Federal Law determines the minimal requirements for the buildings (including engineering network and support engineering systems), and for design processes (including surveying), construction phase, installation, operation and utilization (demolition).

    - Article 7. Mechanical safety requirements

    The structures and basements of the buildings have to have enough strength and steadiness so that the construction and exploitation processes do not threaten the people life, property of physical or legal persons, state or municipal property, environment, life and health of the animals and plants as the result of the following processes:

        a) Destruction of the separate load bearing structures or their parts
        b) Destruction of whole building, or its part
        c) The inadmissible deformations of the structures, building foundation, base and geological massifs of the territory
        d) Damage of the building part, engineering support networks or engineering technical systems in the result of deformation or steadiness losses of the structures, including the deviations from vertical position

    - Article 25. Requirements for moisture protection

1. In the project documentation of the buildings the constructive solutions should be envisaged, which provide:

    a) Drainage from the external surfaces of enclosing structures, including the roofing system, and from the underground building structures
    b) Watertightness of the roofing system, external walls, underground levels walls and floors on the ground
    c) The prevention of condensation on the inner surface of the enclosing structures, except the optical transmissioning of the windows and walls

2. In case it is established in the design assignment, the project documentation should consider actions to prevent flooding of the rooms and structures in the case of the accidents in the water supply systems

2. In 2013 state standard was accepted which regulates the rules of the historical buildings surveys "GOST 55567-2013. The order of organization and implementation of engineering-technician surveys of the objects of cultural heritage. Monuments of history and culture". The standard presents the rules of the following works:

    - Technical conditions for surveying processes of the cultural heritage objects (historical and cultural monuments) of the Russian Federation – the individual buildings, or their parts and elements for the serviceability estimation, determine the restoration necessity and its orientation.
    - The engineer-technician surveys for implementation of the adaptation projects of the cultural heritage objects for modern usage
    - The surveys, which are needed for estimation of the different technogenic effects on the buildings, including construction site works, which are carried out closely to the cultural heritage objects
    - Scientific and methodical guidance of the engineer-technician surveying processes and works related to them

In the Russian Federation, safety of the historical buildings is controlled by the state. The state provides and organizes their reconstruction in obligatory order. There are also situations in which the state withdraws the historical building from the ownership of its owner, because of non-observing the rules of the historical heritage building safety.

In this way in 2015 in Saint-Petersburg for the first time, the state has withdrawn the cultural heritage object from the owner. The law-court carried out the demand for withdraw of the “thriftlessly content” monument – coaching inn of F.N. Slepushkina. This information was reported on the web page of the committee.

The coaching inn of the F.N. Slepushkina is situated on the Slavyanskaya Street, house 1, lit. A, and was determined as the cultural heritage object and was in usage based on the private property rights from JSC “Technopark”. July 6, 2010 KGIOP concluded a building security treaty, but the owner did not carry out the conditions. In 2013 the building was seriously damaged in a fire. The committee three times sent to the law-court the suits about the facts of non-fulfilment of the building security requirements. The suits were satisfied and the organization was fined in total of 320 000 rubles.

Because the building security treaty was not systematically carried out, KGIOP December 10, 2014 sent the suit about the withdraw of the cultural heritage object. April 9, Arbitration Law-Court of Saint-Petersburg satisfied the suit of KGIOP. In addition, the works were carried out in the absence of KGIOP permission, in the Arbitration court of Saint-Petersburg and Leningrad region three protocols about the administrative violation were sent. (Fontanka 09.04.2015).

In this way in the Russian Federation for the historical buildings are planned and carried out the works for their restoration, including the maintenance of the structural technical state, as well as the restoration of the waterproofing protection systems. The necessity of reliable waterproofing system for the building structures are stipulated by the presence of different natural-climatic and soil conditions of building exploitation, in addition – technogenic influences.

In modern conditions with mass spread construction processes of the multi-storey buildings, of the different difficult engineering structures (subway lines, engineer communications and others) the questions about the safety of the cultural heritage objects are very important. In the conditions of compact urban areas of the megalopolis, exploitation of the basement floor of the historical buildings is increased more and more in the quality of the commercial and public zones in Saint-Petersburg. With this often the basement floor is deepened, and in them the hydro isolation reinstalled or restored.

At the real time preservation of the historical buildings of Saint-Petersburg waterproofing area receives considerable attention. The waterproofing questions are studied and developed by the leading universities of the city: Saint-Petersburg State University of Architecture and Civil Engineering, Saint-Petersburg State Transport University and Saint-Petersburg Polytechnic University. Also in the city the large organizations successfully work, which are specialized in the field of the building waterproofing, like LLC “Geoizol”, LLC “Geostroi” and others.

The questions of the building structures waterproofing are very relevant in this time, these questions require consideration of many factors: time, nature, soil, structure, technology and others. Determination of these questions requires a great knowledge of the well-trained specialists, high quality of the works, and competent usage of modern materials and technologies.

3 NATURAL CLIMATIC CONDITIONS

Saint – Petersburg is the city of federal significance, situated in the north-west of the Russian Federation, on the coast of the Gulf of Finland at the mouth of the Neva River. The city covers an area of the mouth of the Neva River, numerous islands of Neva delta. The city stretches from north-west to south-east direction on 90 km. The heights of the city above the sea level in different areas of the city are: in the center – 1-5 meters; in north – 5-30 meters; south and south-west directions is 5-22 meters. The highest position in the city is the Dudergovskie Heights in the area of the Red Village city with the maximum height 176 meters above the sea level. On the territory of the city the zero level mark of the heights and depths system is situated (Baltic system coordinate), which works as the starting point for leveling networks coordinate of several states.

The characteristics of the natural climatic conditions of the construction processes in the Russian Federation are shown in the construction rules document SP 131.13330.2012 "Building climatology". Construction rules determine all natural climatic conditions for the Russian Federation. These conditions are used during the design processes of the different buildings and structures, heating systems, ventilation, air conditioning, sewage, urban and countryside planning and development.

Natural climatic conditions of Saint-Petersburg:

1. The climatic parameters of the cold period of the year:

- The air temperature of the coldest five days period: -30°C
- The absolute minimum of the air temperature: -36°C
- The average day amplitude of the temperature in the coldest month: 9°C
- The duration and average temperature of the air in the period with the average day temperature ≤ 0 °C: 139 days with -0.9°C
- The average monthly relative humidity of the coldest month: 86%
- The amount of precipitation in the November – March period: 200 mm
- The main direction of the wind flow in the December – February period: south-west

- The average wind speed for the period with the average daily temperature of the air ≤ 8 °C: 2,8 m/s

2. The climatic parameters of the warm period of the year

- The average air temperature: 24,6°C
- The absolute maximum air temperature: 34°C
- The average day amplitude of the temperature in the warmest month: 8,2°C
- The average monthly relative humidity of the warmest month: 72%
- The amount of precipitation in the April – October period: 420 mm
- The maximum of the precipitation for the day: 76 mm
- The main direction of the wind flow in the June – August period: west

Table 3.1 Rainfall per April-October period and November-December period (SP 131.13330.2012)

Month	Monthly temperature, 0C	Amount of sediments, mm
April	3,1	420
May	9,8	
June	15	
July	17,8	
August	16,0	
September	10,9	
October	4,9	
November	-0,3	200
December	-5,0	
January	-7,8	
February	-7,8	
March	-3,9	

The information shows the big amount of different, also including negative, natural climatic factors, acting to the building structures of the city.

4 SAINT-PETERSBURG SOIL CONDITIONS

Building foundations of the Russian Federation are situated in very different multiform soil conditions. Because of that it is not possible to consider all the soil conditions in the thesis because of the huge size of the Russian Federation territory.

The level of the foundation footings of the historical buildings is on 2-3 meters below the ground surface level. Depending on the location of the building in the city, the foundations can cross different soil layers:

- Filled-up ground layer. The height of the layer is from 1 to 4 meters. Height in 1 meter is located in the southern parts of the city. Height to 4 meters – on the filled-up areas near the riverbeds and channels. In construction the filled-up ground layer was mostly passed totally
- Layers of peat and peaty soil. The layers exist mostly in the central part of the city on the depth of 2-3 meters. In construction also was passed totally
- Soils of the moraine origin (semisolid loam and clay). These layers are the base for the foundations of the south city part.
- Dusty water-saturated sands. They are the base for the building foundations of the central city part

The clay layers of the southern city part have positive effect on the hydro isolation of the building. These layers are the water-resistant layers for the buildings foundations. In these cases the buildings must be protected only from the surface groundwater and atmospheric sediments.

The most difficult geological conditions are in the central city part. This is because of the high level of groundwater, periodical changes of the water level of Neva River, and type of soils (see chapter 4.3). On this territory it is necessary to install the building hydro isolation systems. Figure 4.1 shows the structure of the geological lithological section of the central part of Saint-Petersburg.

4.1 Lacustrine-marine (Littorina) sediments

In the borders of the city historical center contemporary lacustrine-marine sediments, basically the sands and sandy loam, rarer loam are situated. They have quite a big amount of organic substances. It is quite problematic to use these sediments in the role of the base for the buildings or underground structures. The total height of the lacustrine-marine sediments layers in general is no more than 5 meters. They are represented by the water-saturated dusty sands, dusty sandy loam and loam with quite a big amount of organic substances.

Dusty sands basically have quicksand properties. They easily come to the quicksand state with the changes of hydro dynamic level and creation of extra tension especially variable. Sandy loam and loam should be considered as the weak thixotropic quasi-plastic soils. Layers of lacustrine-marine sediments contain the lens of soil and interlayers of very peaty soils of different structures. These soils have quite a big and uneven compressibility.

These soils are mostly the bases for the building foundations of the historical part of Saint-Petersburg.

4.2 Lacustrine-glacial sediments of the Baltic glacial lake

These lacustrine-glacial sediments, overlying the upper Luga moraine (gIIIos), are widespread, except the separate zones along the Neva River and Neva Bay areas. The total heights of these layers are mainly 3-10 meters, in the island area the total height can be 20 meters. In the cross section of the lacustrine-glacial sediments the clays, loams, sandy loams, rarely sands are mostly situated. In the top part of the cross section the ribbon clays are gradually transferred to the loam and sandy loam. They represent the upper horizon of the ribbon formations, which lost their original exfoliation because of removing by wind erosion, and the weather effects.

Soils of this category are characterized by a high natural humidity and porosity, anisotropy of the mechanical properties, high compressibility, widening in the result of low temperature impacts to the soils, thixotropic.

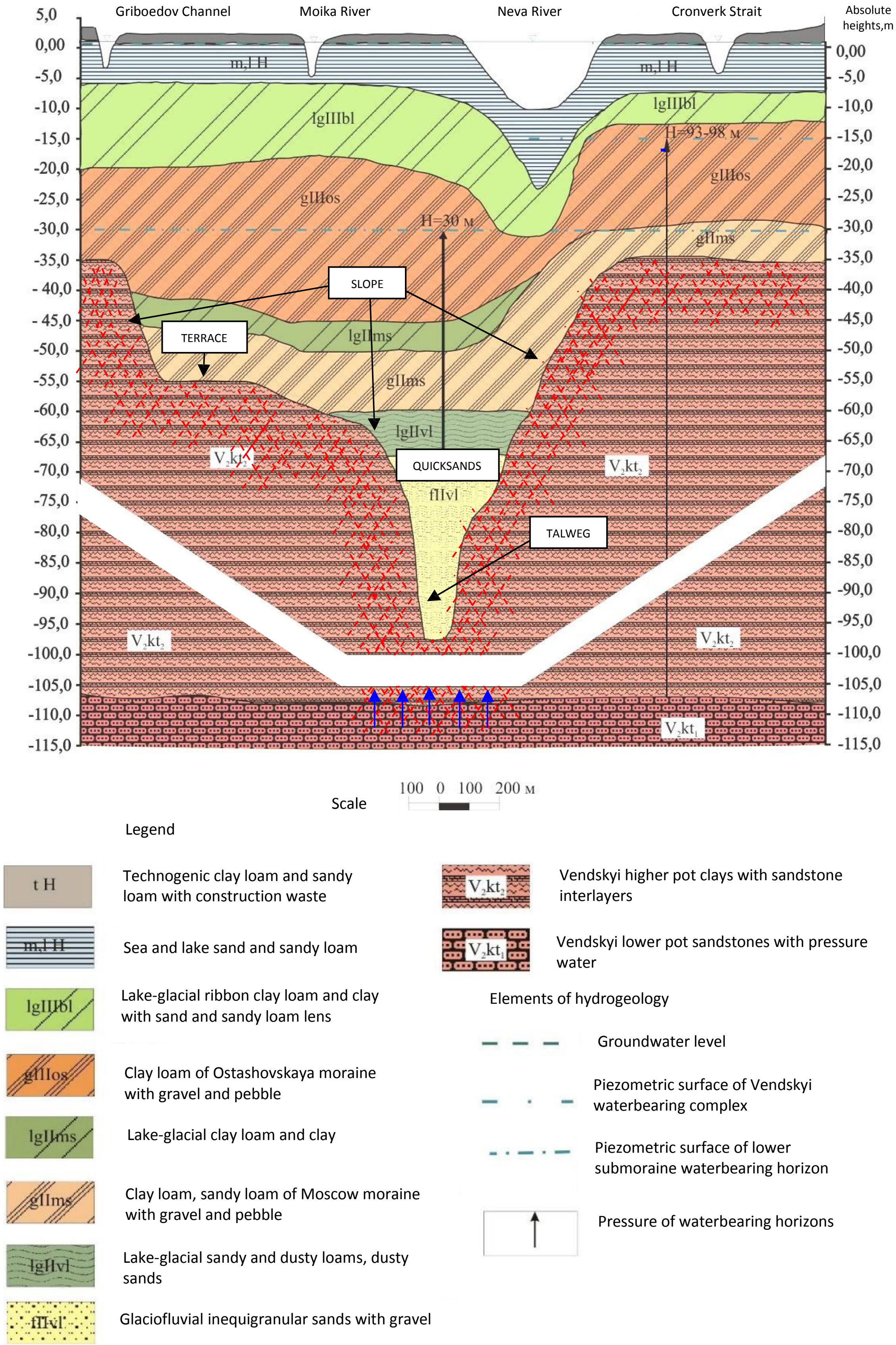

Figure 4.1 Schematic geological lithological section of the buried valley with elements of hydrogeology (Dashko R.E. et al. 2011, p 7)

The soils of the central city part are water-saturated. They are characterized by a significant amount of microbiological defeats, fluid and fluid-plastic consistencies, ability to liquefaction even with small dynamic actions on them and high corrosive activity.

The total height of the lacustrine-glacial sediment layers is usually are not more than 5 meters. The layers contain dusty sands, dusty sandy loam and loams with a big amount of organic materials. In the layers of the lacustrine-glacial sediments the lens and peat interlayers of different structure are contained. The soils have comparatively big and uneven compressibility.

On the city territory the swamp sediments are widespread, which are represented by the peat layers. The height of the peat layers is in the diapason from 0,2 meters to 11 meters. At the moment only the biggest peat lands in the north of the city still exist. They are the swamps Lahtinskoe, Levashovskoe, Pargolovskoe, Shuvalovskoe and others. In the lacustrine-glacial sediments the lens and layers of entombed peats are located. Figure 4.2 shows the location of the swamp areas of Saint-Petersburg in 1698. The biggest height of the peat layers is the height of the upper peat lands, and the smallest height is the height of the peat lowlands. The height of the swamp sediments is 0,5-5 meters, the maximum height is 7-12 meters.

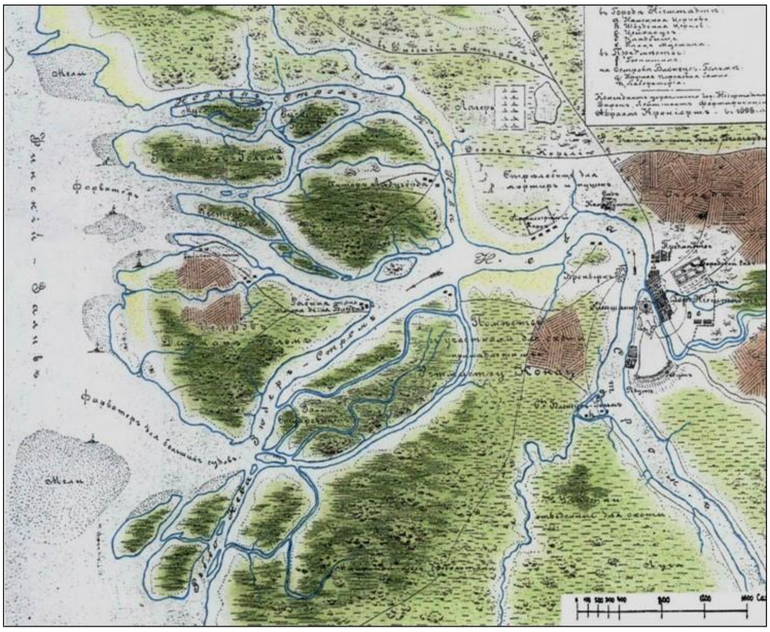

Figure 4.2 Schematic map of the swamps on the territory of future Saint-Petersburg 1698 (Dashko R.E. et al. 2011, p 10)

Soils of this group are characterized by uneven compressibility over time, which depends on the degree of digestion. Dusty sands basically have quicksand properties. They easily come to the quicksand state with the changes of hydro dynamic level and creation of extra tension, especially variable. Loam and clay in the case of water soaking develops their widening in the result of low temperature impact to the soils.

The dominant soils of the south city part, including Pushkin, Petergoph and others are the clay soils of the Luga moraine (gIIIos). Physical properties of the main soil layers see table 4.1. The upper horizon soils of the Luga moraine are the most permanent and clearly traced on all territories of the city. The lower level of the Luga moraine is changed from a few meters to a few tens meters, and in some places it comes on the ground surface level. These “creations” are situated in the north and south parts of the city and locally in the central zone near Vitebsk railway station.

Table 4.1 The main physical properties of the sediments of different age. (Dashko R.E. et al. 2011, p 12)

Rocks	Number of plasticity, %	Dense of rocks , g/см^3		Voids ratio	Natural humidity, %
		Natural state	Skeleton of soil		
Ostashkovskaya (Luga) moraine					
Clay loam and clay	9	2,26	2,05	0,33	10,0
Moscow moraine					
Clay loam	10	2,14	1,87	0,43	13,5
Sandy loam	5	2,27	2,08	0,29	9,7

4.3 Hydro dynamic conditions

On the territory of the city two subtypes of hydro dynamic conditions of the groundwater exist. In peripheral northern, north-eastern and eastern city regions with non-concentrating buildings and an abundance of the green areas the natural, slightly broken hydro dynamic conditions are realized. It is determined by the seasonal climatic changes: pre-spring low level is established from the middle of February to the end of March in the diapason of 2-2.5 meters under the ground surface level, spring maximum level – in April –

May in the diapason of 1-1.5 meters under the ground surface level. With an abundance of rainfall in the summer, which provides a high level of groundwater before the end of the year, the summer-autumn and autumn-winter extremums are greatly smoothed. In these periods the reduction of the annual fluctuation amplitude of the groundwater level is marked.

In the island part of the city hydro dynamic conditions of the groundwater predominantly depend on technogenic factors. Buildings of the city, infrastructure, asphalt coating of the roads and others, all these factors lead to small dependence on climatic factors. Here exist smoothness of the extremal level values and minor annual amplitude fluctuations. Absence of the active drainage zones of the groundwater in the borders of the central city part (in the result of the action of the rabbet protection, embankments of waterways, low absolute height of the groundwater and flat topography) determines their stagnant hydro dynamic conditions and areas flooding.

Flooding processes are stronger in the leakage places of sewage-storm water, water supply and other networks (local cupolas of the extra water pressure arises in these places, which determine a significant differentiation of the groundwater absolute heights), and also because of the condensation processes. In the reality almost all the island part of the city is a flooding area.

Hydro dynamic conditions, which are influenced on the foundation work in the south part of the city, are characterized by the groundwater presence of the “top” water, which has the maximum height level in the rainy periods.

Saint-Petersburg is situated on the Baltic Sea coast. Disposition of the city has effects on the territory flooding. Short-term groundwater level is raised in the periods of strong winds from sea direction. These processes were strong till the completion of the dam construction phase in the Gulf of Finland. The real amount and degree of flooding processes is significantly reduced.

4.4 Hydrochemical conditions of the groundwater

Hydrochemical conditions of the groundwater as well as hydrodynamic conditions are determined by technogenic factors (exception is the periods of flooding). Significant level of the groundwater contamination is fixed almost on the entire territory of the historical center.

4.5 Natural and natural techno genic processes and phenomena

All diagnosable processes and phenomena are divided by the danger criteria into three groups (conditionally):

I – problematic dangerous endogenous processes
II – dangerous exogenous processes
III – exogenous processes with middle and low level of danger

The first group includes the next endogenous processes:

1. Low movement amplitude of the separate structure blocks, which occurs in all disjunctive fractures in vertical direction. With this the territory of Saint-Petersburg, which is dedicated to the crossing junctions of divergent fractures Caledonian, Hercynian, Alpine and modern times of their activation, determines manifestation of the structure type “broken plate” with some movement speed of separate blocks of different sizes
2. Seismic activity of Saint-Petersburg is 5 points at the moment, but many researchers suggest that it should be higher 6-7 points, what will be considered after special researches and realization of geodynamic monitoring
3. Radon danger and deep emanations. Techno genic activity in underground spaces of the city has quite a big influence on migration of radionuclide and radioactive gases (reinforce it or weaken)

Because of exogenous processes of the second and the third groups, to the most dangerous processes should be referred the negative transformation of the sand-clay grounds of Quaternary and pre-Quaternary age with changes of physic-chemical and biochemical conditions. These changes can occur because of not only techno genic factor, contamination for example, but also because of natural conditions activity, in particular, by extensive development of buried swamps and sediments, which has a lot of organic materials. Negative sand-clay ground transformations under the influence of physic-chemical and biochemical factors lead to the development of the following natural-techno genic processes: formation of quick sands, structurally unstable soils, which form the deficit of load bearing capacity of the grounds. It leads to the development of the significant and uneven deformations of the building structures, increasing of the pressure to the base of underground openings, losses of slope stability of the waterways and others. Changes in the physicochemical and biochemical conditions lead to the degradation of not only the soils but also construction materials.

Biochemical gas generation is one of these exogenous processes. Microbial activity forms biochemical gases, which are generated by bacteria of different physiological groups during a conversion process of organic substrates.

Potentially dangerous zones, because of the biochemical gas generation of methane, carbon dioxide and hydrogen sulfide, are the buried swamp massif zones of Saint-Petersburg.

One of the natural processes of medium danger level is the landslides. The process develops on the slopes of the rivers and channels of Saint-Petersburg and influences on the steadiness and normal functioning of embankments, engineering communications and buildings, which are situated along the waterways. On intense development of the landslides in the waterway's slopes areas is influenced the unregulated human activity (losses of technogenic waters, dynamic transport influence).

The southern parts of Saint-Petersburg (cities and settlements Krasnoye Selo, Pushkin, Gorelovo, Skachki and others) are situated on the slope of Baltic-Ladoga ledge (Ordovician ledge) and are situated on the connected with Baltic-Ladoga ledge (from south) Izhora (Ordovician) Plateau, where the karst phenomena can be developed in the sediments of limestone.

The key factors, which control the karst processes of the southern territory parts of Saint-Petersburg, are the slope character of the ledge and lifted karst massif above Prinevskaya lowland, lithology composition of carbonate rocks and their degree of fracturing, height of the overlying Quaternaty sediments, speed and character of groundwater pollution.

Karsts processes relate to the processes, which can be predicted during the territory development, or in evaluate assessments of already built-up areas. Collapse phenomena, which influence the building steadiness, arise quite rare and they are localized in the south-western part of the city only. With proper fullness of geotechnical and hydrogeological information, of ecologic factors information, which provides proper prediction of karst activation, the process can be considered as low-level danger situation.

The most important ones are the following technogenic processes:

1. Big, uneven, prolonged continuous deformation of the buildings and surrounding area.
2. Territory rising by soil filling, because of human or water processes, formation of the technogenic layers (sands, soils, ash, industrial waste and others)
3. Deformations of the buildings, which are situated in the areas of tunnel construction phase because of the soil deformations
4. Losses of steadiness of the base load bearing layers, which are composed by the clay soils in the incomplete consolidation state or affected by freezing-thawing processes
5. Destructions of the soils natural structure with traditional manufacturing methods of the earthworks
6. Quick sand properties phenomena because of dewatering of the open pits and trenches
7. Development of the decay processes of the peat, organic materials in the soils and underground timber elements because of the groundwater level lowering
8. Mechanical soil suffusion with an open dewatering and accidents on the networks

This data about Saint-Petersburg soil conditions emphasize the need, importance and complexity of waterproofing of the building foundations, which are continuously exploited under the influence of the variable groundwater layers and multiple harmful hazards. (TCN 50-302-2004. Appendix D)

5 TECHNOLOGICAL FEATURES OF THE HISTORICAL BUILDING FOUNDATIONS OF SAINT-PETERSBURG

In the Russian Federation, specifically in Saint-Petersburg, the big amount of different structural constructions solutions of the foundations, made of different materials, and by using different technologies, are concentrated.

The foundation types of the historical buildings:

- The strip rubble foundation made of limestone to lime-sand mortar
- The isolated rubble footing made of limestone to lime-sand mortar
- The strip and isolated rubble footings made of limestone to lime-sand mortar
- The strip foundation on the wooden pile base
- The isolated rubble footing on the wooden pile base
- The monolith concrete slab
- The monolith concrete strip foundations

Limestone is widespread rock sediments, which are formed with the participation of the living organisms and bacteria in the sea basins. This rock consists of one material – calcite with admixtures. Limestone deposits are situated near Saint-Petersburg in 40-70 kilometers in the settlement Pudost' and in Putilovo. Because of a good location, easy extraction and processing most of the historical buildings foundations were made of limestone. Limestone bulk strength is 22-30 MPa.

1-2 lower layers of the most building foundations are made of granite. The foundations of Krasnoselskyi Lyceum are fully implemented from granite. Granite in the role of construction material was used only in construction of the important buildings and their parts, because of the difficulty of its preparation and delivery.

Manufacturing technology of the historical buildings rubble foundations

Most of the historical buildings in Saint-Petersburg were constructed in the Neva River floodplain, with the groundwater level, which is close to the level of the ground surface. The laying depth of the foundations was usually taken from 2.5 to 4 meters, it depended on the soil conditions of the construction site. In the past the checking of the soil conditions of the construction site was carried out by a “digging a testing pit” method or by ramming of the test piles.

In the beginning of the 18^{th} century the next architectural monuments with basement floor, which are situated below the ground surface level to 2 meters, were built: Kamennoostrovskyi Palace, Elagin Palace, Sheremetiev Palace and others.

Figure 5.1 demonstrates the technology of execution of the historical buildings foundations consisted of the following points:

- On the construction site the next materials were used: sawn and split limestone, granite stone, lime, sand, logs and boards
- Pits were dug up in hand made way to the planned depth, and the groundwater at the same time flooded the pit
- The wooden rafts were made on the site with width equal to the width of the bottom building foundation. The width of these rafts ranged from 1.5 to 3 meters. Then ready-made rafters were located on the perimeter of the foundation in the open pits on the groundwaters
- The rafters were floated on the groundwater surface, and then they were loaded in the initial construction phase by granite stones with diameter 0.5 meters each. The rafters were drawn and sunk to the bottom of the pit
- Granite stones were placed layer by layer without any mortar to the level of the groundwater surface in two and if it was needed in three layers, usually it was 30-60 centimeters in height, sometimes more. The holes between the stones were filled by the sand and small rubble
- Then on the top of the granite stone masonry, was carried out the masonry made of split limestone (with flat surfaces) to the lime-sand mortar. Foundation top was implemented usually in the ground surface level, or on 0.5-1 meters higher, above the ground surface level

- On the outside foundation part, above the foundation, the exterior walls were protected by the socle, which was made of sawn limestone on the height 0.5-1.5 meters
- The floors of the basement floor were made of 3-5 brick layers to lime-sand mortar or made of split limestone (with flat surfaces) masonry to lime-sand mortar in layer by layer method or all together from these materials

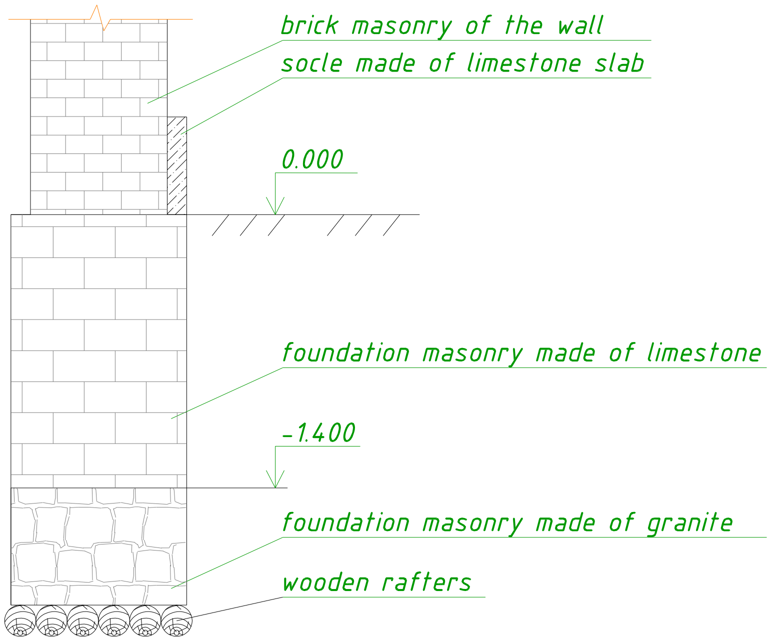

Figure 5.1 Structure of the foundation made in 18th century

Foundations, which were implemented on this technology, were considered as impenetrable structures for the groundwater. It was believed, that limestone masonry to lime-sand mortar can stop the penetration of the ground and atmospheric water to the brick structures of the building. Thus, the foundation structure implemented on this technology was considered as waterproofing structures.

The foundations made of limestone were implemented uniformly from the bottom to the top of the foundation, or, if the building has a cellar floor, from two parts: the outer part was made of limestone masonry to lime-sand mortar and the inner part – made of normal burnt clay brick to lime-sand mortar. In the past it was considered that the limestone is a good hydro isolation material. This constructive decision, as engineers supposed, provided the economy and foundation waterproofing made of limestone and lime-sand mortar to prevent the groundwater impacts. Also any additional waterproofing was not implemented.

In the real conditions the permeability of the structures depends on the quality of implementation.

In reality, in undamaged condition of the foundation masonry made of qualitative sawn limestone with mortar seams with width from 1 to 1.5 centimeters does not better pass the groundwater through the foundation to the structure than in bad implementation. In the real conditions the foundations of the historical buildings are made not from sawn limestone with good parallelepiped forms, but from split limestone with comparative observing of the blocks sizes and proportions. Accordingly masonry seams between the stones are not ideal 1-1.5 centimeters, they have different size from 1 to 4 centimeters. Also the mortar filling areas are different, there are more pores, defects and voids, accordingly – very high possibility of water insertion through the structures exists in these areas.

Rubble foundations of the historical buildings, which are made of limestone masonry, are different in the production quality, materials quality, technology quality, are in the different, very distinguish technical state from each over. For example, the palaces foundations, which were built in Russia 1700-1800, have almost no damages, but the foundations of the profitable houses, which were built 100-200 years later, can be seriously damaged.

In the result of the physical deterioration under the impacts of different negative factors, the foundations, which are exploited 100 years and more, got different physical damages, as well as structural damages of the materials (by water elution and leaching of the lime-sand mortar and others). Existing damages of the historical buildings foundations move on the first plan the necessity of the waterproofing systems. It is very actual in mordern urban conditions, because of the desire of the effective exploitation of the buildings underground levels.

6 REASONS OF DAMAGES OF THE HISTORICAL BUILINDGS FOUNDATIONS

Reasons of the damages of the historical buildings of Saint-Petersburg are different. Conventionally the following reason groups exist.

6.1 Uneven deformation of the wooden building foundations

Uneven deformation of the wooden building foundations develops because of a rot destruction of the wooden logs and piles, which are situated under the foundation footing. Long time of exploitation in the conditions of aggressive impact and factual reducing of the groundwater level at the present time, provides reducing of the strength characteristics to 30-70 percent of the rafters wooden logs with diameter 180-250 millimeters, which are situated under the foundation footing. Figure 6.1 demonstrates that in some places under foundation footings, with no groundwater at all, the wooden logs are totally destroyed by rot.

Figure 6.1 Apraksin Yard, house 4, Saint-Petersburg. Totally destroyed wooden logs because of the rot processes

Presence of the capillarity moisture in the upper soil layer is provided by the following reasons:

- Drainage in the conditions of dusty water-saturated sands until recently time, in fact, was not used and implemented. This was done to avoid the removal of the dusty sands and ground setting
- Some buildings have the lawns, which provide the free water access to the soil
- Removing of the water from the roofs of the historical buildings is made directly on the surface of the pavements, which have damages. Removing of the atmospheric water directly to the sewage system was made only on the important buildings

In original, wooden rafters and logs foresee as one of the working parts of the foundation in the position where the logs are situated below the groundwater level without possibility of oxidation with the rot development. At the real time hydrogeological conditions of many different city parts are changed because of the technogenic influences during the construction phase. Under the foundation footing of some buildings the wooden foundation parts are totally destroyed.

For the same reasons the destruction of the tops wooden piles in the foundation is happened, accordingly because of it the deformations of the next buildings structures are developed. Figure 6.2 shows the case of destruction of the topes of wooden piles.

Figure 6.2 Apraksin Yard, house 4, Saint-Petersburg. Destruction of the topes of wooden piles

6.2 Uneven level of the groundwater

Because of the groundwater movements from foundation top to bot parts and back, mortar between the limestone masonry layers is gradually destroyed by water. Actually at the real time in the outer foundation masonry layers the lime-sand mortar does not exist from the outer side of foundation on the depth from 30 millimeters to the width of the one masonry layer, which depends on the specific conditions and times of the building exploitation.

Development of the masonry damages occurs with increasing from top to the bot parts. Masonry mortar can be fully destroyed by water from one to four masonry layers. In this case foundation with rectangular form takes the loads with the same mechanic's principles, but it becomes very sensitive to any outside and dynamical impacts. In the foundations with trapezoidal shape, which are widening downward, the widened part can be turned off from the foundation system – if the masonry does not contain any mortar. The loads in this case are transmitted on the reduced foundation footing area, and because of that the pressure on the foundation base is increased, therefore the foundations deformations are developed, and that leads to the structures deformations.

6.3 Destructive damages of masonry materials

Damages of the socle building part, as well as the foundation surface damages on the width of the one masonry layer, happen under the influences of water and frost in the winter time. Actually the destructive damages of limestone bricks and masonry mortar are occurred in the socle to a height of 0.25-0.35 meters above the ground level and below the ground level to a depth of 1 meter. The reason for that is limestone, depending on its type, it has a porous or lamellar structure. Groundwater or atmospheric water with entering in the pores or joints in the winter time freezes and produces gradual destruction Figure 6.3 shows the result of these effects.

Figure 6.3 Destruction of the foundation masonry made of limestone and lime-sand mortar after prolonged influence of the water and frost

As the result the groundwater or atmospheric water gets an access through destructed limestone masonry parts to other building structures.

6.4 Background dynamical impacts to the building structures

The exploitation of the building foundations in the central part of Saint-Petersburg happens in the conditions of the continuous dynamical impacts, because of the heavy traffic on the streets of the city. The foundation base of large buildings, which are situated in the central city part, is dusty water-saturated sand, which can change its own physical properties under dynamical impacts. That sand can lose its physical properties totally, or it caulks depending on the degree and type of load or impact. Long-term monitoring recorded that annually the immersion of the building foundations of Saint-Petersburg historical part in the soil occurs on 1 millimeter. In the central part of Saint-Petersburg with building surveying it is determined that ground level at the time of building construction phase is below than existing level on 0.6-0.8 meters. Socle top of the historical buildings, which height is 400-600 millimeters, exists in the ground level or slightly higher, or lower, which is the result of these processes. Brick masonry of the walls in some buildings is located in direct contact with the soil and exists under the impacts of the ground and atmospheric water.

6.5 The impact of a new construction

The incorrect conduct of the construction works on the building site of the new buildings in the dense urban areas leads to the foundation structures damages of neighbor buildings. The most important reasons of damages are the following:

- Dynamical impacts of moving and driving mechanisms. The disstructuring of the water-saturated dusty sands and dusty clay soils, on a construction site of the surrounding territory occur because of them
- Changes of the groundwater level because of water pumping out of pits. Insignificant water pumping from the depth no more than the depth of the foundation level does not have any affect practically. But pumping during a long time period in big volumes can lead to the uneven deformations of the neighboring foundations because of leaching of the dusty sands under the foundation footing
- The weakening of the base soils, because of the underground works and development of pits. The deformations of the foundation structures of existing buildings can occur because of development of the trenches and pits below the level of foundation footing around these buildings. Also subway tunnel structures and other underground structures in a varying degree lead to the foundation base and building structures deformations (Mangushev R. et al. 2011, pp 32-33)

6.6 Technogenic influences

In the result of low culture of exploitation and organization of the maintenance building system, because of the installation processes of the a new engineer networks, the building foundations are destroyed in many places by engineering networks passing holes, which are sometimes carried out without any structural foundation reinforcement and following restoration. The consequence of this is the progressive deformations of the building structures (Figure 6.4).

Figure 6.4 Damages of the foundation in the place of the entrance of the engineer networks. Replacement of destroyed limestone in the socle by bricks

Lack of coordination between the various service organizations in the works implementation of installation or repairing of the engineer systems or other kinds of works in the building area lead to the building damages. With groundwater pumping can develop an uneven deformation of the building foundation, because of losses of load bearing capacity of dusty sands, water-saturated sands, which are situated under foundation footing.

Superstructures or extra loads for the building foundations, without any assessment of the factual exploitation conditions, also lead to the building damages. Usually extra storeys increase the load on the building foundation and if this building does not have any foundation recalculations and strengthening, it leads to the uneven deformations of the building foundation and structures.

6.7 Aggressive impacts

Aggressive effects include also the leaching of lime-sand mortar from the seams of the foundation masonry. Under the influence to the foundation materials of different chemical reagents, which are contained in the groundwater, in the result of masonry mortar destructions, the same processes occur as with uneven level of the groundwater (see chapter 7).

7 AGGRESSIVE IMPACTS TO THE FOUNDATION STRUCTURES

Physic-chemical corrosion

Oxidation of the foundation materials (corrosion - carbonization) occurs under the influence of oxygen and water during building exploitation.

Under the impact of the fresh (soft) water (condensation, rain) on the concrete or lime-sand, cement masonry mortars, the calcium hydroxide (CaOH) is leached from them. With leaching of the $Ca(OH)_2$ firstly becomes destructions of the cement stones, then develops the destruction of the clinker materials. Leaching of CaO in amount of 15-30% is the main reason for reducing of the material strength.

Leaching of calcium hydroxide from cementitious materials leads to the leaching of other substances, as result the materials become porous and they are gradually destroyed. Because of that on the material surfaces white sags are formed. (Fedosov S. et al. 2003, p 13)

Chemical corrosion

The second type of corrosion includes the processes of corrosion, which develop under influence of the water, which contain chemical substances. This chemical substance reacts with the components of the concrete and mortar. Products of these reactions are soluble and can be washed by the water. It increases porosity of the materials. As a result of the reactions gelatinous growths can be created, which has no binding capacity.

- Quite common is the magnesian corrosion (7.1), which occurs under the action of the magnesian salts. For example, if the water contains magnesium chloride, then in the connection with cement stone, magnesium chloride will destroy cement stone

$$Ca(OH)_2+MgCl_2 = CaCl_2+ Mg(OH)_2 \quad (7.1)$$

- The industrial wastewater may contain hydrochloric acid, which affects the building foundations, and causes materials salt corrosion and destruction.

$$Ca(OH)_2 + 2HCl = CaCl_2 + 2H_2O \quad (7.2)$$

Under the influence of acids, hydrochloric acid, for example, with calcium hydroxide, highly - soluble in the water salts $CaCl_2$ is created (7.2). The result of reaction is salt leaching and weakening of the foundation structures (Fedosov S. et al. 2003, pp 17-20)

Another type of chemical corrosion combined the processes, in development of which in the pores and capillaries of the material crystallization of low-soluble salts is occurred. It creates significant stresses in the walls of capillaries and pores, which limit the growth of the crystals. As a result extra stresses are created to the walls of pores and capillaries. To this type of corrosion can be referred the corrosion processes under impact of sulphates, where the destruction is caused because of growth of the gypsum crystals and sulphate calcium aluminates. Aggressive impacts of the gases are determined by their form, concentration, temperature and relative humidity of air, and speed of exchanging of aggressive environment. Speed of corrosion increases in simultaneous action of the chemical and physical factors. Corrosion processes are strengthened under external mechanical actions.

- In the traffic and industrial activity a significant amount of carbon dioxide CO_2 is created, which in combination with water creates carbonic acid. Under impact of the acid $Ca(OH)_2$ connects with atmospheric carbon dioxide with creation of dissoluble salt and water (7.3)

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O \quad (7.3)$$

Crystals CaCO3 not just fill the pores, in their big amount they seek to expand pores, to destroy them. As the result the material begins to crack, destruction of material of the foundation structures is occurred

With an excess of water further materials transformation is the following:

$$CaCO_3 + CO_2 + H_2O = Ca(HCO_3)_2 \quad (7.4)$$

After that reaction pores are created and material is destructed

- Similar actions create also other acids except polysilicon and silicon-hydrofluoric acids, which strength the structure of materials of the building foundations (7.5)
- The groundwater can contain a large amount of sulfates, which in the reaction with calcium hydroxide form the gypsum (7.6), are deposited inside the foundation structures. It leads to the formation of internal stresses in the structures, with their subsequent cracking

$$Ca(OH)_2 + H_2SO_4 = CaSO_4 + 2H_2O \quad (7.5)$$

$$Ca(OH)_2 + Na_2SO_4 = CaSO_4 + 2NaOH \quad (7.6)$$

- Various oils, which contain fat acid (the oil and oil products as petrol, oil, kerosene apply to a material significantly less damage than others) (Kind V. et al. 1934, pp 254)

Alkaline corrosion of the foundation materials

In high concentration of alkalis in steam generated water can be dissolution of the protection layer of magnetite Fe_3O_4 (7.7).

$$Fe_3O_4 + 4NaOH \rightarrow 2Na_2FeO_2 + Na_2FeO_2 + 2H_2O \quad (7.7)$$

Then new formed ferrites under impact of water are resolved in the following way:

$$2Na_2FeO_2 + H_2O \rightarrow 2NaOH + Fe_2O_3 \quad (7.8)$$

Furthermore alkaline in high concentration reacts directly with iron:

$$Fe + 2NaOH \rightarrow Na_2FeO_2 + H_2 \quad (7.9)$$

Biological corrosion

Biological corrosion also leads to the foundation material damages. In exploitation porous foundation structures are exposed to the lower forms of living organisms: bacteria, fungi, algae, mosses and lichens. In addition the foundations made of small blocks can have biological effects from the plant roots. There are three options for effects:

- In the porous materials microbes and bacteria settle in the material of the structure. Microorganisms, which destroy the foundation materials, are in direct contact with the structure. The process of metabolism of microorganisms is the worst period for the material, because all of its quality deteriorate and reduce lifespan of the structures. Adhesion of the constituent components is violated as the result of impact of the mineral or organic acids of microbial origin. Gradual destruction of the material is occurred, also its strength reduced, reduced the term of exploitation of the structures.
- Biological organisms, which are not in direct contact with the foundation materials, but because of technogenic areas, are situated near to foundation, even at a distance from material can make serious damage to the foundation structures. This corrosion develops in the zones of high humidity, presence of ample amount of organic substances and materials (ammonia, fat, salt solutions). These conditions develop very actively the microorganisms – biodestructors, which destroy the structures made of inorganic materials and convert them into organic materials (see figures 7.1-7.2)
- The next effect is a combination of the first two effects with water activity and variable temperatures. The material pores, which are increased in sizes in the result of the microorganisms activity, are soaked and subjected to destructive frost destruction (Fedosov S. et al. 2003, pp 58-59)

Figure 7.1 Water leakages through brick masonry. Salt sediments on the walls and floor

Figure 7.2 Biological destruction of brick masonry as a result of hydro isolation malfunction

The following types of destruction processes also effect on the material of the foundation and its structure

1. Material corrosion of the foundations under the combined impact in the autumn-winter period to the structures of the water and frost also leads to the foundation materials damages. Water, which penetrates into the pores of materials, with frost expands, and creates application of the inner stress to the stone, which destroys the structure. Repeated cyclic repeat of the process develops the materials degradation (structural destruction)
2. Electrocorrosion of the foundation materials – under the influence of an electric current (stray currents, leakage currents) as the result of electrolytic and electroosmotic processes

3. The impacts as a result of technogenic processes: minerals and salts as anti-freeze reagents and others

4. Rooting processes of the wooden parts of the foundations (logs and piles) as the result of lowering of the groundwater level

5. Gas aggressive environments. Of these, special attention should be on the hydrogen sulfide gas. Foundation material in that environment is subjected to corrosion with increasing of sulphates in the composition of foundation material, also reactive sulfuric acid is formed. Aggressive factor is the carbon dioxide in atmosphere (especially in industrial zones). Material of the structures is destructed, atmospheric carbon dioxide when reacts with lime, converts the last one in limestone. With this alkalinity of the material is reduced, its strength also reduced.

Grade of aggressive impact depends on not only from composition of aggressive environment, but from conditions of contact, from movement speed and pressure of the liquid environments, density of the soil in action of groundwater, temperature of environment, loads, natural-climatic conditions, actions of exploitation field. (Kind V. et al. 1934, pp 258)

8 SERVICE EXPLOITATION CONDITIONS OF THE BUILDING FOUNDATIONS IN SAINT-PETERSBURG

All service exploitation conditions can be separated on two groups: natural conditions and technogenic exploitation conditions.

Natural conditions:

- High level of the groundwater
- Constant influences of the groundwater with alternating level. Constant movements of the groundwater determine the destruction of masonry mortar of foundation masonry and other high intensity aggressions. Including high depth of soil freezing in the winter time
- Possible aggressive impacts of the chemical substances on the structures and foundation materials
- Annual periodic influence of low, including alternating outdoor air temperatures in the winter time to humidified structures

Technogenic exploitation conditions of the historical buildings of Saint-Petersburg:

- Possible impacts to the structures and foundation materials of harmful industries
- Impacts to the foundation structures and materials because of pollution
- Presence of significant amount of networks and necessity of their passing through the building structures
- Influence of neighboring buildings construction on the structures and building foundation materials
- Significantly increased traffic saturation from 17th-19th centuries (see table 8.1)

Table 8.1 Comparison of traffic saturation in 17th-19th and 21st centuries

Index	17th-19th centuries	The 21st century
Vehicle weight, kg	200÷300	500÷15000
Vehicle speed km / h	20-30	60÷80
The presence of dynamic effects on structures	-	+

9 NECESSITY OF WATERPROOFING

Historical buildings of Saint-Petersburg have serviceable and effective systems of hydro isolation, as well as faulty systems. Some buildings have no waterproofing. These buildings have quite a big amount of damages, types of which are mentioned earlier. The development of these damages determines the technical condition of the building structures. Installation of the effective waterproofing systems is impossible before the structures will not be repaired. For example, the building waterproofing is impossible if in the underground foundation level any cracks and holes exist. There is no sense to deal with waterproofing systems if the reasons of foundation cracks formation are not removed. Hydro isolation of the building structures is a big complex of arrangements, materials and systems, which prevent the water penetration into structural elements of the building. Installation of the enclosing structures includes three stages, which are helped to make the inner part of the building waterproof and ecologically safety:

- Understanding of the building structural integrity
- Understanding of the most probable reasons of water appearance, which affects the structures
- Restoration and strengthening of the building structures when it is necessary
- The installation of the systems, which prevent the water penetration into the structures
- Ensuring of the connections between adjacent elements of each element of the building envelope

Water influence to the underground structures can be considered as the impact:

- Short term, because of precipitations or pipeline accidents and others
- Long term, because of moisture presence in the soil
- Long term, because of the groundwater presence
- Short term or long term duration as the impact of complex factors to the damaged during exploitation period structures of the building

Melt water, rain water as well as casual waste water falls into the ground and fulfills the pores between soil particles. Under the influence of its own weight the water descends into deeper layers. The speed of its movements depends on the coefficient of the soil filtration.

Groundwater is water, which retains in the soil by adhesion or capillary forces. It always presents in the soil independently from the presence of the groundwater horizon or weather sediments. The quantitative and qualitative state of the water in the soil massif in this case depends on the soil properties.

Constant impact of the water is stipulated by presence of the groundwater level, which changes dependently on a terrain relief and position of the water impenetrable layer.

In contrast to the effects of the groundwater and water from weather sediments, the capillary waters do not make any hydrostatic pressure to the structures, if constructive solutions provide the unhampered run-off and removal of the groundwater without creation of the dead zones. But in the spring period in the soils with low penetrability the impact of filtered water to the structures makes a strong effect, which must be considered. (Shilin A. et al. 2003, p 17)

The main reasons for water appearance

Water with high possibility comes through the building envelope of the above-the-ground structures as weather water and through the underground structures as groundwater. Depending on situation, also should be considered other reasons for water appearance: melting snow, landscaping sprinklers or sources such as gutters, including faulty drainage ditches.

For leaks the presence of any of these reasons is insufficient. For creation of the leaks must be carried out next three factors. At the first, in the system the water in any of its aggregate states should exist. In the second, some types of forces should be acting to the water. And the most important factor is that the integrity of the building envelope should be broken (there must be a break, rupture or hole), what will provide the water penetration into protected area.

Water comes to the inner part of the structure under the impact of multiple forces, which are:

- Gravity forces
- Surface tension
- Wind load/air flows
- Capillarity effect
- Hydrostatic pressure

The first three forces usually occur in the building envelope area above the ground surface level, and the last two – in the zone of the building or structure in the ground surface level or below it.

For the elements of a building envelope, which are situated above the ground surface level, the main force factor, which causes the water penetration, is the gravity force, so it should not be designed as absolutely flat or horizontal surfaces. The water should run-off from the structure freely and fast, which hinders different passageways, balconies, and other necessary flat zones. The more freely and faster the water will run-off from the structure, the less leakage there is.

Surface tension effect is manifested in the water movements to the moist building materials surfaces in horizontal or in reverse directions to the material surface. This situation happens very often in the masonry seams: the water comes into the building structure under the influence of the surface tension force. Figure 9.1 demonstrates that effect.

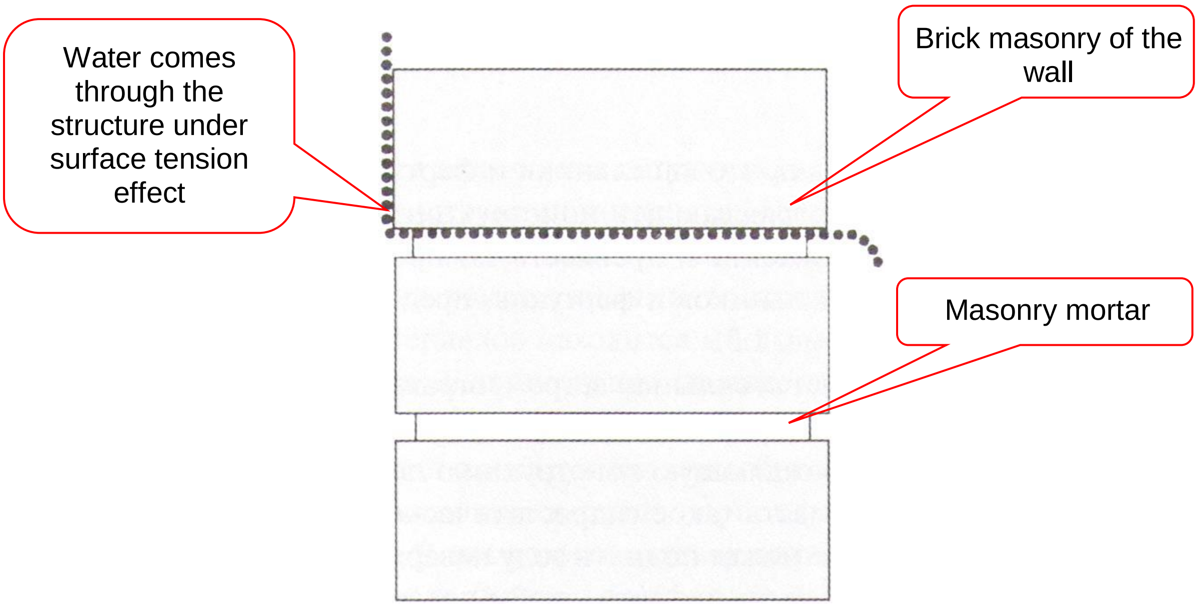

Figure 9.1 Example of surface tension effect on brick masonry of the wall (Cubal M. 2012, p 15).

If the rain is accompanied by the strong winds, the building envelope becomes significantly more sensitive to the water penetration. Besides the fact that the water comes through the building envelope directly with wind flows, wind can cause a hydrostatic pressure to the building envelope, which can lift the water up even through the building envelope.

Capillarity effect occurs in the situations, when the water is absorbed by surface of building envelope by capillarity moisture spreading. Capillary phenomena exist on the border of two environments – liquid and gas. It leads to the curvature of the liquid surface, and makes it convex or concave. Gravity force between water molecules and surfaces of capillary is higher than between the water molecules. Because of this the water near the wall of capillary rises – it is the capillarity effect. Capillary force raises the water until the level, where hydro static water pressure becomes equal to the capillary force. The thinner capillary, the greater capillarity forces and water rises up higher.

Mostly this situation occurs with brick masonry or concrete part of the building envelope structures, which are located in the ground surface level or under the ground surface level. Within these materials there are many tiny pores, which make them sensitive to the water capillarity penetration. These pores in the case of the big water accumulations create the capillarity forces, which suck the water in the building envelope surfaces like a sponge. Concrete is a porous material, and its pores are the same capillaries. Water by using them will spread upward and inward to the structure. If foundation footing is based on the wet ground, then the water will rise up by using its footing. It will come to the wall and come further. Subsequently it will lead to the destruction of the foundation body and walls.

Materials, depending on the pore distribution and amount of small pores, can be less or more sensitive to the capillarity effect.

Hydrostatic pressure normally affects the underground structures of the building envelope, which are under the effect of the groundwater. Hydrostatic pressure at any point of the structure creates by the weight of the water column, which is situated above that point. This pressure can be significant, especially in the underground areas, where the groundwater level is originally near the ground surface level or rises to that level during heavy rains. Water under hydrostatic pressure will search the weakest places of the building envelope – the ends of the elements or element connections.

10 TYPES OF THE ORIGINAL WATERPROOFING OF THE HISTORICAL BUILDINGS

The features of the technology, construction and exploitation of the historical buildings foundations of Saint-Petersburg are described earlier in the thesis. This chapter describes the variants of structural waterproofing in the construction phase in the XVII – XVIII centuries.

1. Foundation waterproofing
2. Hydro isolation of the basement floor structures
3. Blind area of the building
4. Socle
5. Hydro isolation of the walls

9.1 Foundation waterproofing

Hydro isolation was carried out in 2 ways:

1. The constructive way:

In the construction building phase during the XVII – XVIII centuries the masonry was carried out with significant foundation thickness – 1-3 meters of thick limestone with lime-sand mortar. For a long time it was thought that limestone masonry with lime-sand mortar implements the role of the effective waterproofing. The foundation limestone masonry was made with the laying depth of 2-4 meters, and above the foundation top on 0.5 meters. In vertical cross section of the foundation, the foundation masonry of the external walls was carried out with continuous form, or with ledge from inside to outside (in the case of presence of the basement floor in the building).

In the first case the brick masonry was carried out from the foundation top (figure 10.1). In the second case the brick masonry was carried out from lower foundation ledge made of limestone. Figure 10.2 shows the principle of this kind of foundation. In this case the outer foundation part was made of the split bedding limestones, and the inner part was carried out by the bricks. Foundation masonry of the external walls was carried out by 3-5 masonry rows made of limestone higher of foundation bed. These variants of masonry implementation were used to provide the waterproofing of the structures because of hydro isolation properties of limestone and lime-sand mortar.

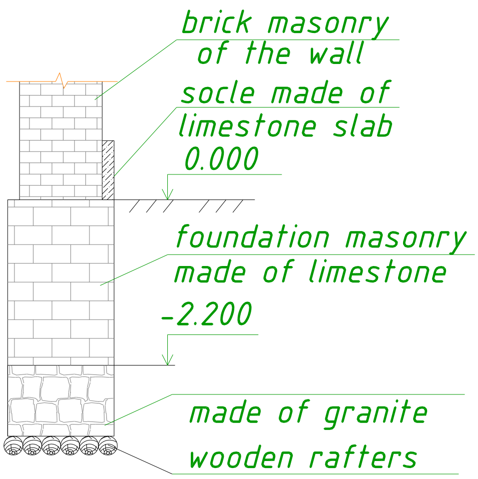

Figure 10.1 Foundation of the 1st type

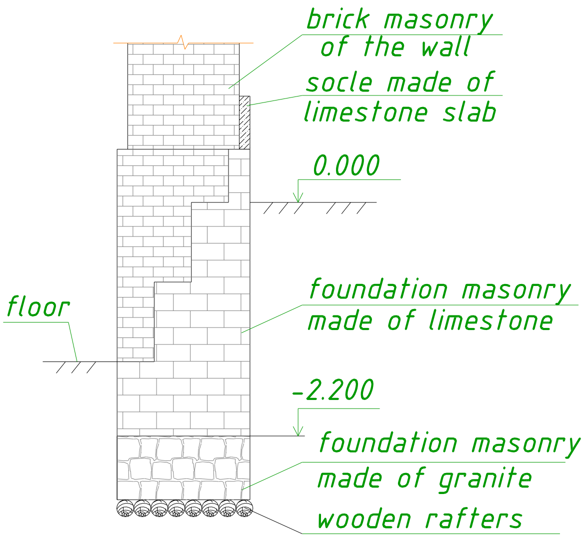

Figure 10.2 Foundation of the 2nd type

During the deposition of limestone, different clay particles are connected and deployed to the rock. Because of this the rock becomes clay, layered, strength and hydro isolation properties are deteriorated. If the foundation stones contain the clay layers, during the exploitation the stones will be gradually destroyed. It happens because of the groundwater and natural impacts to the stones. As a result through these destroyed foundation parts the groundwater gets a free access to the protected structures and intensively penetrates into them.

In Saint-Petersburg in the building on the Mohovoi Street, house №40 foundation waterproofing is ensured by application of precisely sawn limestone in the foundation masonry. Masonry seams are 0.5-1.0 centimeters in height. Because of a good implementation of the foundation works the groundwater did not come to the walls brick masonry.

2. Application of the hydro isolation materials of natural origin

Clay lock.

The integrity of foundation masonry is important for ensuring the waterproofing of the building structures. Foundation masonry made of limestone did not provide an absolute hydro isolation of the building structures. In especially important cases for reliable waterproofing from the outer foundation part, hydro isolation was made by clay lock with the width of 30-50 centimeters to the whole foundation height. Technology of implementation of the clay locks:

- Production of the clay without admixtures
- In the special troughs the clay was soaked till the state of very dense jelly
- Clay mortar was installed layer by layer into the trench, or formwork, pre-formed along the foundation
- After laying clay was rammed to homogeneity
- Installation was made on the perimeter of the basement, without any breaks to the entire height of the basement from the foundation footing to the ground surface level.

The effectiveness of the clay lock waterproofing in Saint-Petersburg soil conditions, is provided by the high level of the groundwater, cool and humid climate. These conditions do not allow the clay lock to dry during long exploitation period. Clay lock is effective in the plastic state. At present the clay lock is a highly effective and reliable type of hydro isolation of the building structures. Examples of the clay lock are Kamennoostrovskyi Palace, Saint-Petersburg and Bolshoi Palace, Peterhof (figure10.3-10.4). Works on the clay lock installation have a significant material consumption, require a lot of manual labor, and significant work time. Because of these reasons the clay lock as hydro isolation in contemporary construction is not widespread. The clay lock will work as a highly effective waterproofing system only with its high quality of implementation. Any interlayers of sand, any foreign admixtures as the component of the lock create the possibility of groundwater penetration to the building structures.

Figure 10.3. Kamennoostrovskyi Palace. Foundation waterproofing by the clay lock

Figure 10.4. Bolshoi Palace, Peterhof. Foundation waterproofing by the clay lock

Blind area made of limestone slabs to the concrete preparation

Clay lock

Foundation of an external wall

Brick masonry of an external wall

Historical passageway in the foundation, without any hydro isolation - for the engineer networks

Socle made of sawn limestone to the lime-sand mortar

Clay lock can be used in the real time, but it is not used because this method of waterproofing is non-industrial and non-technological**.**

The next type is the waterproofing of the foundation masonry from the outer side by a large limestone slabs, with lime-sand mortar below the ground surface level.

Hydro isolation of this type is used in the Peter and Paul Fortress in Saint-Petersburg in the house №6B (figures 10.5-10.6). Figures 10.7-10.8 show that on the object the limestone slabs with sizes 1x0,5 meters are used, they are assembled vertically to the building foundation end, which go beyond from the wall level. The slabs are made of limestone and have width from 80 to 100 millimeters. The slab edges are precisely sawn in the form of rectangle. Seams between the slabs are embeded by lime-sand mortar.

Figure 10.5 Peter and Paul Fortress, the house 6B

Figure 10.6 Location of the building

Figure 10.7. The outer vertical foundation waterproofing of the house №6 A, which are made of limestone slabs, and installed vertically to the foundation end

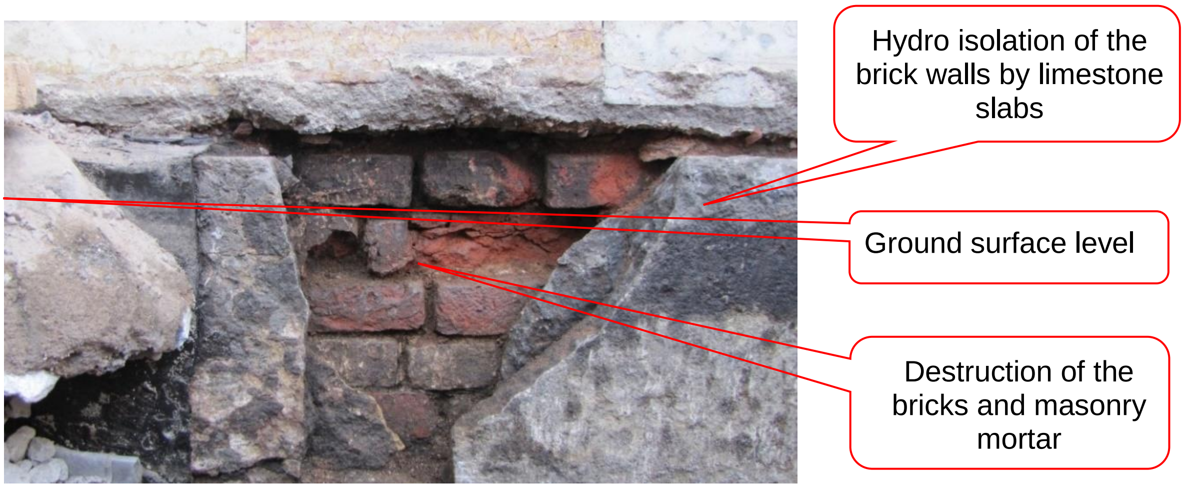

Figure 10.8 Elution and damages of limestone, brick and masonry mortar, the house №6 A

9.2 Hydro isolation of the building structures of the basement floor

1. To ensure the hydro isolation between foundation and brick walls a layer of lime-sand mortar in height 25-30 millimeters was installed. For a long time it was believed that this structure does not pass the capillary moisture from the foundation to the brick masonry.

2. In the wooden buildings to ensure the hydro isolation between the foundation and the walls the birch bark was used. These structures were found in Rimsky-Korsakov Museum in Tikhvin, Leningrad region (see figure 10.9), and in a family house Dobbert in Saint-Petersburg (see figure 10.10). The exploitation term of these buildings is 150-200 years.

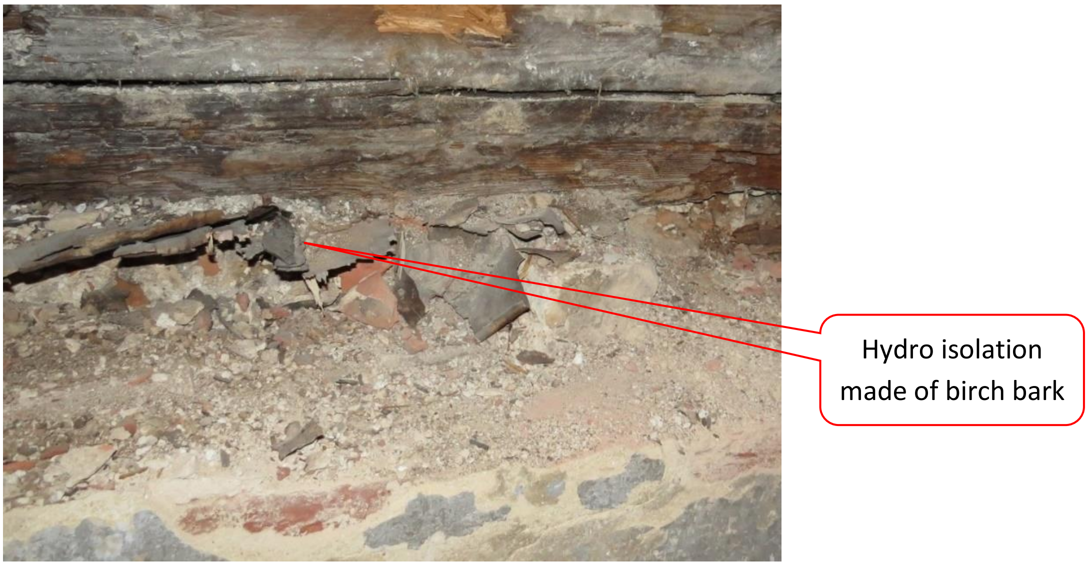

Figure 10.9 Saint-Petersburg, Big Pushkarskaya street, house of Dobbert, the house №14, hydro isolation between the foundation and wooden wall, made of birch bark

Figure 10.10. “Tikhvin, Leningrad region, Museum of Rimskyi-Korsakov, hydro isolation between the foundation and wooden wall, made of birch bark layer”

3. In some buildings of Apraksin Yard in Saint-Petersburg as the part of the rubble foundation, which is made of limestone, the hydro isolation layer made of burnt ceramic tiles was found.

4. For buildings with basement floor, the floor waterproofing was provided in 2 ways:

   – By lining of 2-3 masonry layers made of limestone to the lime-sand mortar (figure 10.11)
   – By clay lock as the part of the floor structure (figure 10.12)

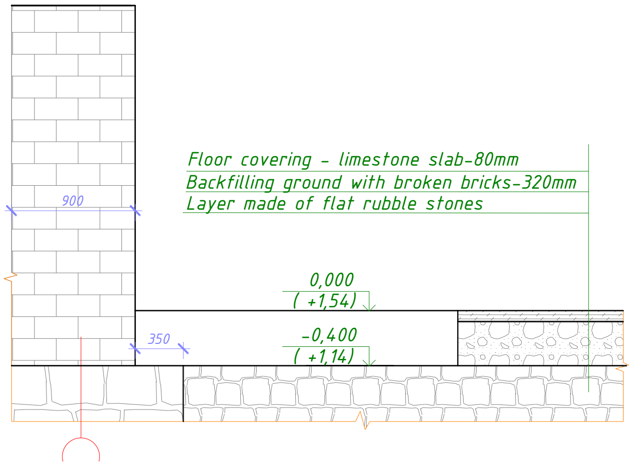

Figure 10.11 Elagin Palace. Saint-Petersburg. The foundation of the internal wall. Lining of 2 layers of limestone masonry as the floor basement

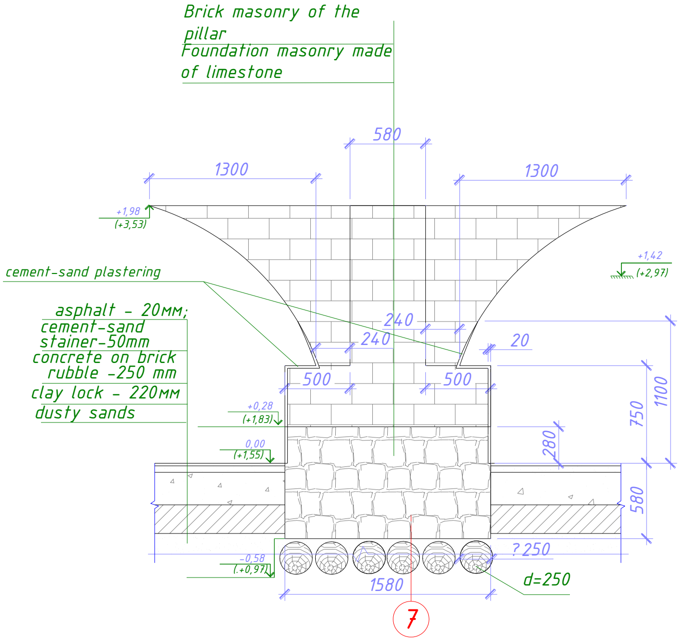

Figure 10.12 Kamennoostrovskyi Palace. Saint-Petersburg. The foundation of the internal brick column. Wooden pine-tree logs d=150 mm. under the foundation footing. Clay lock in height 220 mm in the floor structure

9.3 Blind area

Blind area is an important part of the building hydro isolation system. The purpose of the blind area is to take away the atmospheric water from the walls and foundations and prevent the damages of the ground surface near the walls and materials of the walls from the falling atmospheric water from the roof. Typically, blind area was made of the small granite stones. In the building with high responsibility, the blind area was made of sawn limestone slabs with a minimum slope 3%. In the case of insufficient water removing, insufficient slope begins the development of biological damage on the structures surfaces (moss, mold, plants). The roots of the plants destroyed the material structure, in the formed pores and holes comes the atmospheric water and groundwater. This water in the winter time will destroy the structure of limestone, mortar masonry, bricks and the other materials (see figures 10.13-10.15), including the materials of the walls bottom and top part of the foundation. Then in these structures the destruction of the bricks, limestone and mortar masonry develops.

Figure 10.13 Peterhof. Alexandria 1

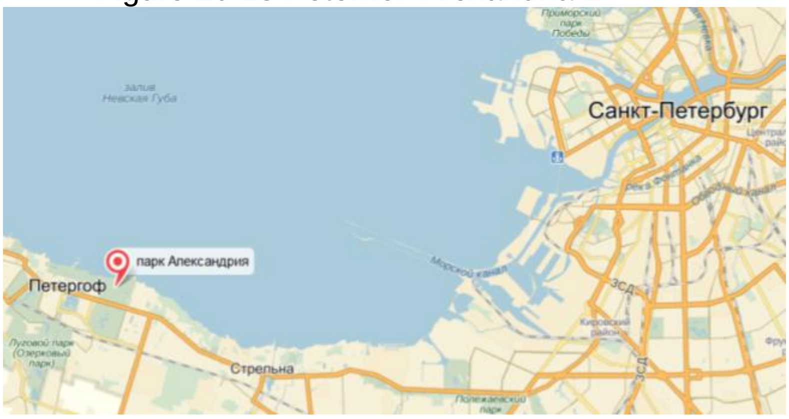

Figure 10.14 Location of the building

Figure 10.15 Blind area made of small granite stones. Insufficient water removing from the wall. Soaking of the materials and developing of the bio destruction by plants and mold

Blind area, which is made with high quality and correct slopes, provides the structural integrity of the walls and foundations. Figures 10.16-10.18 show the qualitative implementation of the blind area was carried out on the Grand Palace, Peterhof.

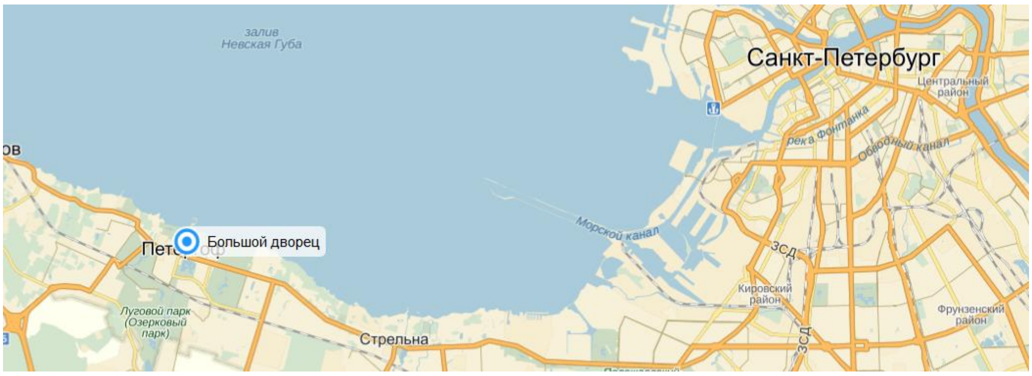

Figure 10.16 Location of the Grang Palace

Figure 10.17 Peterhof. Grang Palace. Socle made of sawn limestone to the lime-sand mortar. Blind-area made of limestone. Heated outfall from the roof into the sewer network

Figure 10.18 Peterhof. Grang Palace. Socle made of sawn limestone to the lime-sand mortar. Blind-area made of limestone. Heated outfall from the roof through the outer drainage gutter

9.4 Socle

The lower part of the walls is equipped with waterproof structure, called the socle. The purpose of the socle is protection of the lower part of the walls from atmospheric water, and sometimes from groundwater. The socle is arranged with the height from 0.5 meters and higher. For the buildings with high responsibility, palaces, the socle was arranged from the foundation footing with the height up to 1,5-1,8 meters and higher the ground surface level. Following types of the materials were used for the implementation of the socle:

- For the stone buildings – masonry made of sawn limestone slabs (see figure 10.17-10.18), or granite slabs (see figure 10.19) to the lime-sand mortar or embedment of the masonry seams by plumbum
- For the wooden buildings – planking of the lower part of the walls in vertical or horizontal way (see figure 10.28)

Figure 10.19 Peterhof. The Museum of the Imperial yacht. Foundation masonry made of limestone. Socle made of granite blocks to the lime-sand mortar or embedment of the masonry seams by plumbum. Blind area made of asphalt

Typical damages of the building socle for a long time exploitation:

- In the exploitation period with historical buildings of Saint-Petersburg happened the deformations of foundations and increasing of the ground surface level. Because of this, nowadays the top of the socle of many buildings is in the ground surface level or lower. Brick masonry above the ground surface level is not protected by the socle, and soaking by the atmospheric water (see figure 10.20-10.23).

Figure 10.20 Saint-Petersburg, Pestel Street 3A

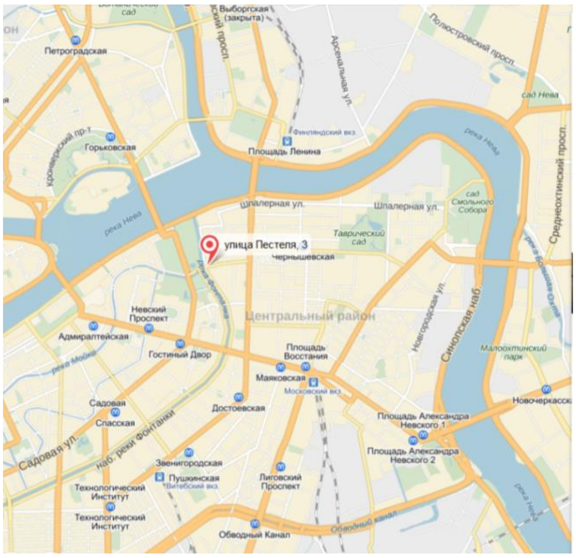

Figure 10.21 Location of the building

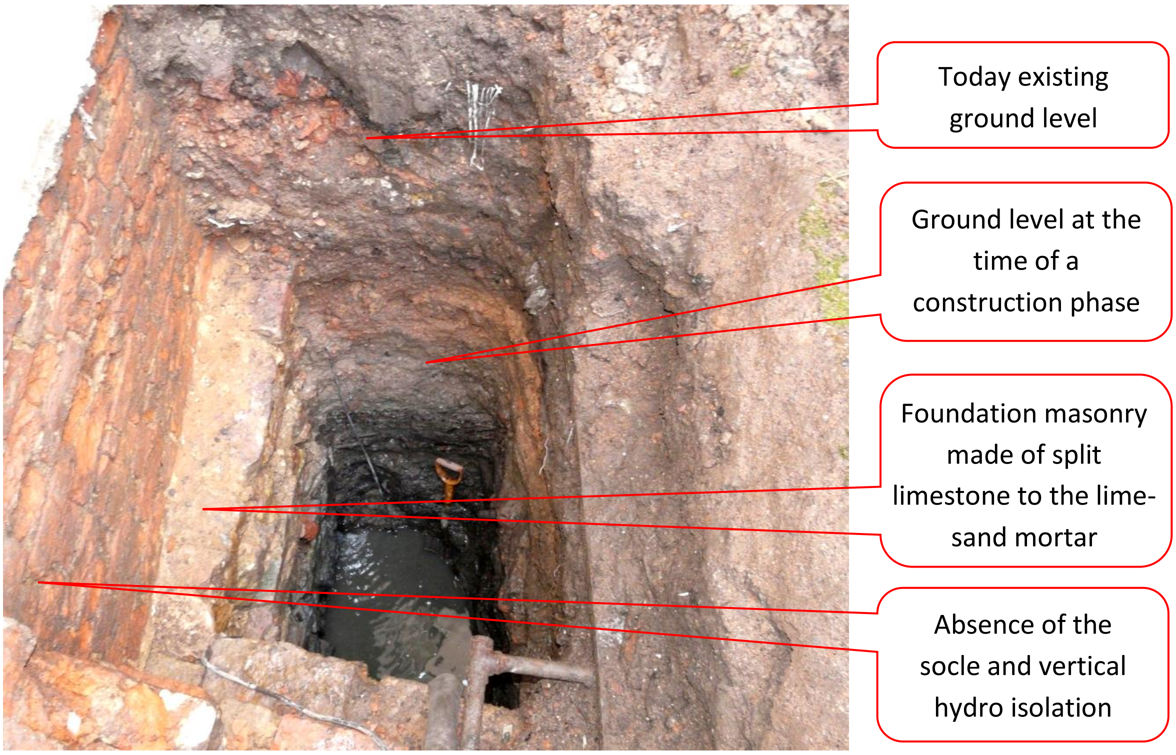

Figure 10.22 Saint-Petersburg. Pestel Street house 3A, 2012 year. Foundation of the longitudinal wall of the building. Absence of the foundation waterproofing. Socle is not made. Absence of the hydro isolation between foundation and wall. Absence of the vertical hydro isolation of the brick masonry of the wall. Direct contact of brick masonry with soil on the height to 1 meters

Figure 10.23 Elution of the lime-sand mortar of the foundation masonry to the depth of 1 brick layer as a result of elution during long building exploitation period (>100 years)

- Limestone is a layered material. During a long exploitation term with frequently repeated temperature fluctuations from negative to positive a multiple limestone soaking with moisture penetration through the capillaries in the stone layers with following freezing in the period of a low of the temperature are happened. When water freezes in the stone pores, the ice expansion and gradual destruction of the limestone structure happens. Destructed limestone loses its waterproofing properties and passes the water to the structures.

- Figure 10.27 shows the mechanical damages of the socle and foundation material in the process of the engineer networks installation.
- Figures 10.24-10.26 show the elution and leaching of masonry mortar in the long term period of the building exploitation in the real. Appears the possibility of groundwater access to the structures through the holes in the foundation masonry and capillaries.

Figure 10.24 Saint-Petersburg, Sadovaya Street, the house 8/7

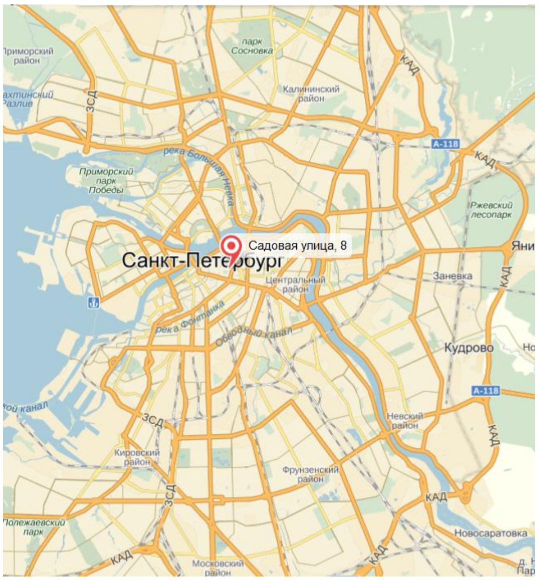

Figure 10.25 Location of the building

Figure 10.26 Saint-Petersburg. Sadovaya Street house 8/7, 2008 year. Elution of the masonry mortar in the outer layer of the foundation in the period of a long building exploitation (>100 years). Absence of hydro isolation. Absence of vertical foundation waterproofing

- Damages of the foundation masonry and socle by cracks as the result of developing of uneven deformation for various reasons (see figure 10.27).

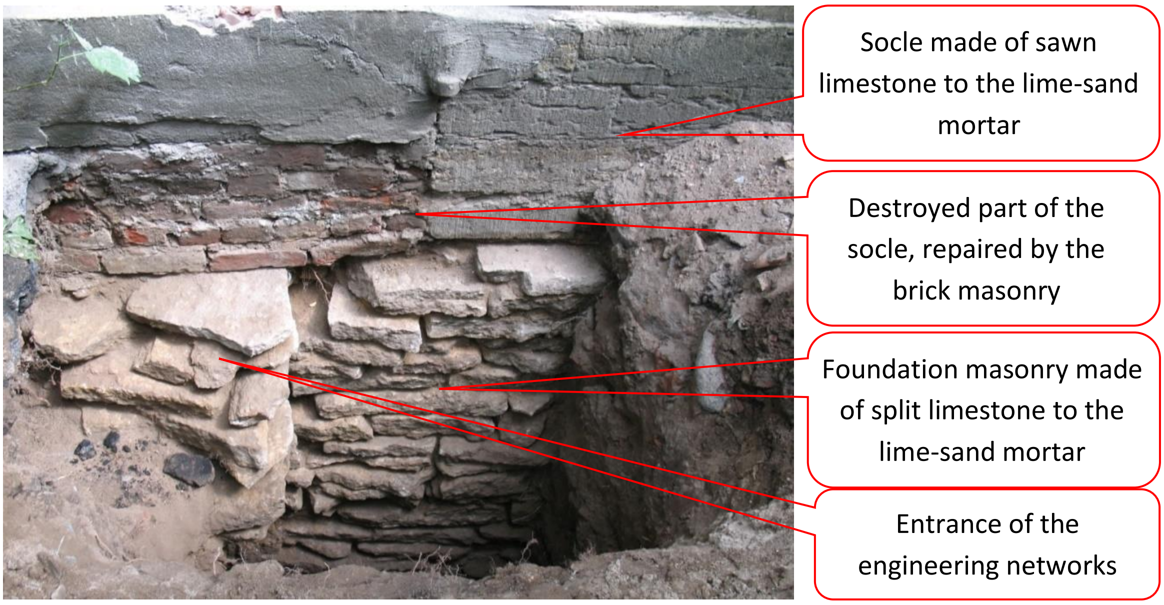

Figure 10.27 Saint-Petersburg. Sadovaya Street house 8/7, 2008 year. Foundation of the longitudinal wall of the building. Absence of the foundation waterproofing. Damages in the place of the engineering networks entrance. ½ part of the socle is under the ground surface level. Absence of the masonry mortar in the outer masonry layer. Absence of the hydro isolation between foundation and wall. Absence of vertical foundation waterproofing

9.5 Walls waterproofing

Above the foundations the walls were equipped with the different installations, which protected them from the atmospheric water and provided removing of the water from the structures:

1. Surface of the walls of the historical buildings of Saint-Petersburg was protected by lime plastering, which has waterproofing properties
2. Surface of the terraces were made of sawn limestone slabs, marble, granite to the lime-sand mortar, or embedment of the seams by plumbum
3. Terrace hydro isolation provided by hydro isolation made of plumbum with covering above the sand layer and limestone slabs

Walls were equipped also in the following way:

1. Figures 10.28-10.30 demonstrate the main elements of the buildings made of wood. The main cornice to the top of the walls and the secondary cornices – in the inter window space made of brick masonry, limestone slabs, timber. Cornices had the stone coating or by sheets of iron and copper

2. Cornices above and under the windows equipped with the limestone slabs, steel, in the wooden buildings – wooden plank (figures 10.28-10.30)

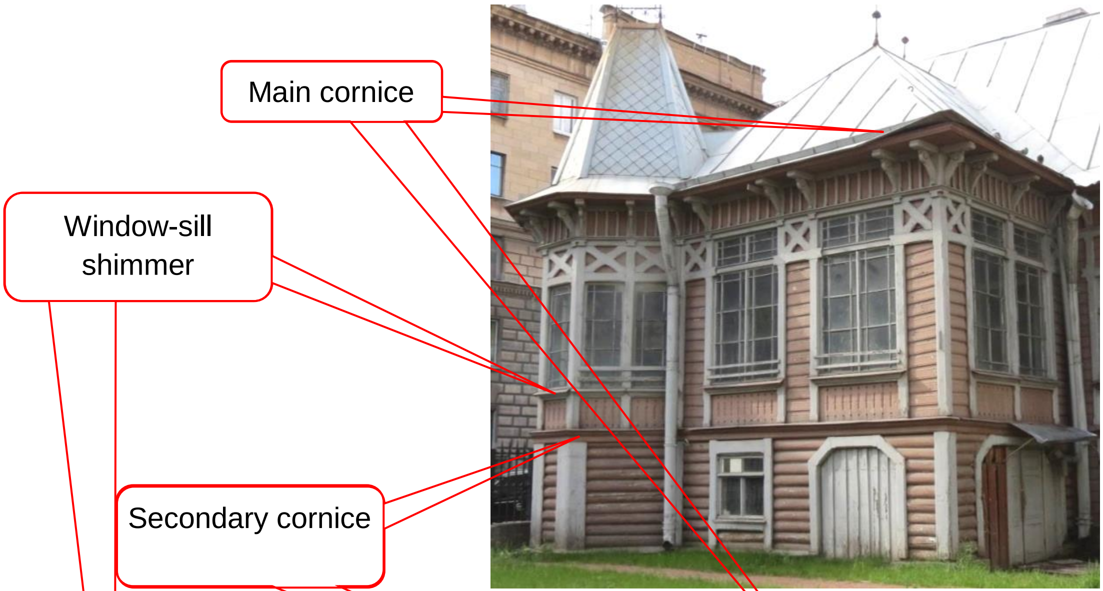

Figure 10.28 Saint-Petesburg, Bolshaya Pushkarskaya Street the house №14

Destroyed church Putilovo settlement, Leningrad region

Figure 10.29 Window-sill shimmer made of limestone slab

Figure 10.30 Devices of the wall hydro isolation

3. The intermediate cornices made of limestone slabs above the socle in the structures, which are located from the outer building part
4. Figures 10.31-10.35 show the entrance galleries, porticoes, abat-jour above the entrances

Figure 10.31 Main and secondary cornices

Figure 10.32 Destroyed top of the foundation, destroyed socle, top of the socle

Figure 10.33 Vishnyi Volochyok, Leningrad region. Railway station building, main cornice made of brick masonry

Figure 10.34 Pushkin. Paley B.G. Palace. Main and secondary cornices made of brick masonry, cornices above and under the windows made of steel sheets

Figure 10.35 Pushkin, Aleksandrovskyi Palace. Porticoes, abat-jour above the entrances and entrance galleries

5. All the waterproofing structures, which protect the wall structures, work in the complex with other roof structures, drainage structures, which are not the subject of the thesis

At present the hydro isolation of many historical buildings needs the restoration:

- As a result of long-term exploitation
- As a result of physical deterioration
- As a result of influence of complex of negative factors, which are mentioned in chapter 6

It is very important to recover and provide hydro isolation properties of the historical building and monuments structures to prevent their gradual destruction and preserve the heritage for future generations. It is advisable to use time-tested materials and modern technologies. In the dense building planning of Saint-Petersburg arises the question of full usage of underground building spaces. There is need to protect the basement floor of the historical buildings from the groundwater and atmospheric water.

11 HYDRO ISOLATION OF THE HISTORICAL BUILDINGS

11.1 Variants of the buildings waterproofing in the period 1700-1900

More and more in the dense urban development of megalopolis the basement floors of Saint-Petersburg historical buildings are exploited for commercial and public premises. With this appears the necessity to make the basement floor deeper, restoration or re-installation of the hydro isolation systems. Because of the Saint-Petersburg soil conditions, great age of historical buildings, it is necessary to make foundation reinforcing of these buildings and for effective exploitation is necessary to repair the existing hydro isolation system, or install a new waterproofing system.

At present many different types of hydro isolation exist. The main principles of any waterproofing is the work of the system to the positive or negative pressure of the groundwater, to prevent the capillary moisture, water vapor, to protect the building and its structures from the soaking by the atmospheric water and groundwater.

Hydro isolation systems to the positive pressure

Systems to the positive pressure are installed on the side of structure, on which acts directly hydrostatic water pressure. The opportunities of these systems are:

- The systems prevent the direct hit of the water to the base layer of hydro isolation system
- Base preparation layer is protected from the cycles freezing - thawing
- Base preparation layer is protected from the effect of corrosive chemicals in the groundwater.

The disadvantages of these systems are:

- For installation of hydro isolation system to the just-made concrete preparation layer of the monolith structures, the structure can not solidify properly
- Waterproofing system is not available for the processing and repairing after installation

- For hydro isolation of the horizontal foundation parts it is necessary to implement the concrete preparation layer and drying of the soil

Hydro isolation systems to the negative pressure

Hydro isolation systems to the negative pressure are installed on the opposite to the systems to the positive pressure side of the structure.

Advantages of these systems include the following:

- Available after installation for processing

Disadvantages of the system:

- Only cement systems can be used, which can be applied on the inner surface of the structure (example of the cement system – cement-based repairing mortar of the Vandex series)
- Base preparation layer is not protected from the cycles freezing - thawing
- There is no protection of the base layer or steel reinforcement from the groundwater and chemicals

Systems to the positive pressure are widespread in the construction of the buildings at the moment. These systems hinder the building structures from the water penetration with chemical admixtures, rising of the water to the upper structures; protect the reinforcement in concrete form corrosion. These systems are difficult to access during exploitation, for repairing works it is necessary to implement the earthworks.

Systems to the negative pressure are more characteristic for using in already made buildings. The main advantages of these systems are easy accessibility to the system after installation. Most of these systems are used for reconstruction (Cubal M. 2012, pp 56-57).

The projects for building hydro isolation systems are created and performed by special project organizations, of which the leading organizations in Saint-Petersburg during the last 10 years are LLC ”Geostroy” and LLC “Geoizol”. The thesis submits the selection and analyses of the technical solutions of actually executed projects of the historical buildings and palaces in Saint-Petersburg, developed by one of the leading organizations in the field of foundation construction and hydro isolation – LLC “Geoizol”.

11.2 Constructive solutions of the hydro isolation systems

Hydro isolation is the complex of the materials and systems, which prevent the water penetration to the structural elements of the building. Providing the waterproofing of the structures of historical buildings is a complicated process. The works have to be carried out with already made structures, which are exploited for many years, with the materials, which have significant physical deterioration and different damages.

Providing of the waterproofing of the historical buildings is produced by the following technical solutions:

11.2.1 Installation of the monolith reinforced concrete waterproofing caissons

Installation of the reinforced concrete caissons is one of the most effective design solutions in the projects for reconstruction of the waterproofing of the building basement floors in Saint-Petersburg.

Considering variant of waterproofing was used on a significant amount of the historical buildings of Saint-Petersburg. The considered further constructive solutions are used on the following objects:

- The Alexander Palace. Constructive solutions to the basement deepening and waterproofing (appendix 1, sheets 1-2).
- Saint-Petersburg, Galernaya Street, house 19; Anglyiskaya Embankment, house 20, Zamyatin Lane., house 2. Basement waterproofing (appendix 1, sheets 3-4).
- The adaptation for contemporary usage of the building located at: Central District, Konyushennaya Square, house 1, lit. A, in a hotel complex (appendix 1, sheets 5-6).
- Saint-Petersburg, Mayakovskyi Street, house 36-38. Apartments redesigning for offices of CJSC “Pilon” (appendix 1, sheets 7-8).

- FGBUK “GMZ” Peterhof” Saint-Petersburg, Kolonistskyi Park, Olgin Island, lit. A. Restoration of the basement floor with installation of hydro isolation and drainage system (appendix 1, sheets 9-10).
- FGBUK “GMZ” Peterhof”. Restoration of the socle floor of the Verhnesadskyi house, located at: Peterhof, Pravlenskaya Street, house 11 (appendix 1, sheet 11).
- Saint-Petersburg, Isaac’s Square, house 9, Pochtamskaya Street, house 2. Complex waterproofing of the building and waterproofing of the basement floor.
- Deepening and waterproofing of the basement floor of cultural heritage building at address: Saint-Petersburg, Nevskyi Avenue, house 58.
- Saint-Petersburg, Nevskyi Avenue, house 48, lit. A. Complex building structures of the basement floor protection from moisture and foundation strengthening.

Monolith reinforced concrete caissons can be established in two types. The first type – load bearing caissons, they are used in the case of necessity to strengthen the building foundation structures, which also execute the functions of waterproofing structures. The second type is the waterproofing caissons, the structures, which execute the waterproofing function, protect the basement exploited floor from the water penetration, but do not perform the function of strengthening of the foundation structures. Monolith reinforced concrete caisson consists of two parts: reinforced concrete slab and reinforced concrete foundation enlargement. (figure 11.1). To provide the effective operation of caisson, the body of caisson partially fastens to the foundation toothing, with anchorage of the reinforcement to the building walls, to provide the combined work of the structures.

Figure 11.1. General view on the reinforced concrete caisson. Corridor of the basement of the Alexander Palace

The top of the reinforced concrete foundation enlargement is on 0.5 meters higher of the maximum groundwater level. Because of the Saint-Petersburg soil conditions and high level of the groundwater in the historical buildings usually the caissons are installed. They implement the works of load bearing caissons and of waterproofing caissons at the same time.

Monolith reinforced concrete caissons, which are executed after calculations, are carried out in the following way. The monolith waterproofing reinforced concrete slabs are designed with height 200 mm, concrete class B25 to the strength, with grade W6 of waterproof, with a filler fraction 20-40 mm, with vertical reinforced concrete foundation enlargement 150 mm thickness. If the hydro static pressure on the structure is more than 0.6 MPa (in the conditions of Saint-Petersburg in the construction of the deepened structures, which are below the ground surface level on 2-3 storeys), then concrete with higher grade of waterproofing is used in the case if the project does not provide any other measures of protection. Reinforcement of the slabs is made of the armature with class A400C ∅14, step 200 mm in two rows. This solution of the monolith reinforced concrete caisson is used in reconstruction, restoration, technical re-equipment and adaptation of the Alexander Palace for museum usage.

An important feature of the monolith reinforced concrete caissons is a correct execution of the cold seams in the concrete joints during concreting. In the first place in the production of the works by method of continuous concreting in the floor level the basement reinforced concrete slab is installed, which is necessary at least 28 hours to hardening. After this period, the works to the reinforced concrete foundation enlargement installation are begun. Because the works to concreting are in the different times, concrete of the foundation enlargement and slab do not create a united massif, between them the cold concreting seam is formed. This seam creates the possibility of the groundwater penetration through the structures. Hydro isolation of the cold seams in the concrete is the most necessary and important part of the hydro isolation protection of the building. Also the cold concreting seams in the joints of the concrete slabs are created because of the stops in the concreting processes, and they are waterproofed.

Water isolation of the seam is provided in the following way:

1. The installation of a caulked cord made of bentonite in the joints of concrete slabs connections
2. The installation of hydro isolation connectors in the joints of concrete slabs connections
3. The installation of inject-system separately or together with the other systems to the joints of concrete slabs connections

1. The installation of a caulked cord made of bentonite in the joints of concrete slabs connections

Hydro isolation of the cold concreting seams performed during formwork phase, by the installation of the bentonite cord, and punching of the longitudinal gab in the surface of concrete 30x30 mm and its embedment according to the project in the end of 28 days period. Works on waterproofing are carried out according to the rules of the system installation.

2. The installation of hydro isolation connectors to the joints of concrete slabs connections

According to the typical schemes of the building seams capsulation, which are developed by LLC “Geoizol”, into the middle of the working concreting seam of the cross section of external wall and connection seam of the wall-floor system hydro isolation connector "LLC Geoizol GP 160” is installed. Hydro isolation connector is a flat bar made of galvanized iron, which has on both sides a special polymer coating. Figure 11.3 shows that on the both sides the coating is closed by film, which is removed immediately before concreting. Connection of the special coating with not strengthened concrete hinders the water filtration through the cavity of the seam. Installation of the isolation connector is performed after the end of the reinforcement works (before floor or walls concreting, see figure 11.2).

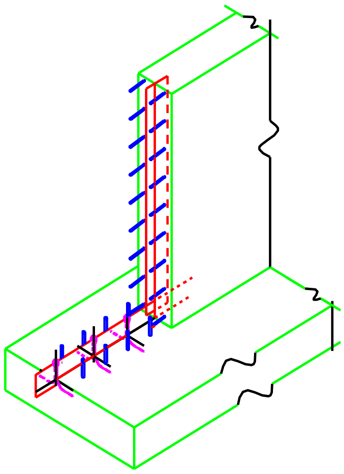

Figure 11.2 Installation scheme of the profile GP 160

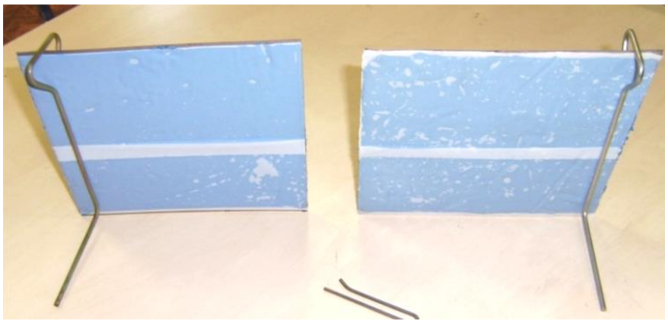

Figure 11.3 Connector “Geoizol GP 160”. Mounting brackets

Connector GP 160:

- -Length of the element is 2000 mm
- -Width is 167 mm
- -Thickness is 3 mm
- - Capsulation of the concreting seams
- - Capsulation of the contiguity seams
- - Temperature of exploitation from –600^{0}C to +1400^{0}C

Because of polymer bitumen coating the connector provides capsulation of the seams with deepening to concrete to the depth 30 mm and more.

3. The installation of inject-system separately or together with the other systems to the joints of concrete slabs connections (figure11.5).

The installation of the inject-system is used in the connection wall – floor system. This inject-system provides the watertightness of the cold concreting seam. The main feature of the system is an easy accessibility to the system after its installation, and possibility of additional measures to improve the watertightness properties of the cold concreting seam.

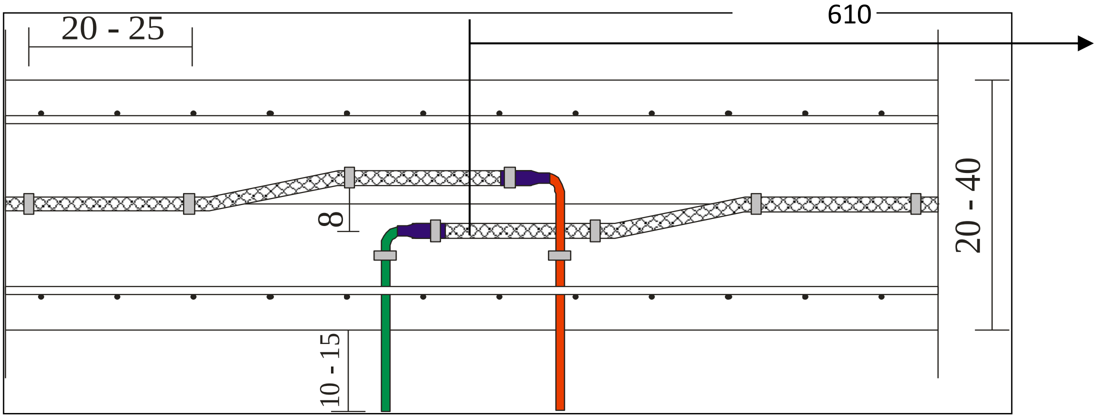

Figure 11.4 Installation scheme of the inject-system in the construction joints (cm)

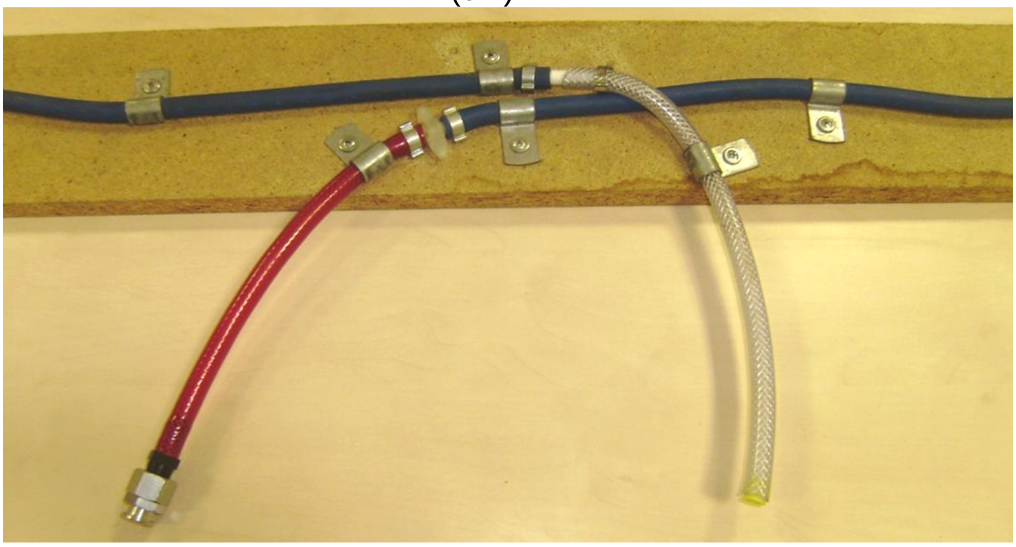
Figure 11.5 Inject-system

In the installation the following principles must be followed:

- The concrete surface of the foundation slab must be flat. Figure 11.4 demonstrates the main principles of the system installation. Firstly installation of the inject-system is made by using the special staples with step 200 mm. Inject-system is mounted by the sections no longer than 6 meters, the bringing pipes are installed to the both ends of the inject-system section. The sections must cover each other in length no less than 200 mm

- Installation of the inject-system in the construction joints, which are formed because of the stops during concreting processes. The bringing pipes are fixed to the armature fittings, the ends of pipes are mounted to the plastic boxes for electrical wiring, which are fixed to the formwork or on slab surface at the distance not less than 150 mm. The ends of the pipes are installed and oriented to the internal surface of the reinforced concrete foundation enlargement or slab. To provide the flat surface for mounting of the inject-system, the cuttings, which are formed because of the stops during concreting processes, are made of wooden desk or plywood. Installation of the metal grid as a cutting is strictly prohibited

- Before application of the hydro isolation covering and before flowrate of the inject-system, all the cracks and seams with width more than 0.2 mm are jointed as gab. The gab is made by perforator with pike. The minimum size is 30x30 mm, the maximum is 40x40 mm. The gab is cleaned by the compressed air under the pressure. On the cleaned concrete surface inside the gab is applied the binding layer of the repairing mixture. The mixture is applied by a hard brush. The concrete surface during application should be moist, presence of the puddles, flowing down water and any free water is prohibited. To the fresh binder layer applies the work repairing mortar Vandex CRS RM 05. On the connections wall – floor, the seam is made with the execution of the fillet on the works seams, which are created because of the stops in the concreting processes, in the same in-plain of the concrete surface

- Flowrate of the inject-system is made by using the low viscosity acrylic resin “CarboCryl Hv”, setting time is 7-10 minutes. Flowrate of the works seams, which are created because of the stops in the concreting processes, of the slab and the walls are made before the object letting to the exploitation, but not before the concrete takes its project strength. Flowrate of the inject-system in the seams “wall-floor” is made in case of necessity. Before the system flowrate in the works concreting seams of the external walls is necessary to make their jointing from the inner side as gab with size 30x30 mm and make an embedment by the low-shrinkage repair mixture based on the cement

- From the inside the application of the hydro isolation material to the whole floor area and reinforced concrete foundation enlargement is made

- In the places of reinforced concrete foundation enlargements the connection with existing walls of the basement floor is necessary to make an apron by the material "Vandex BB75E" in two layers.

11.2.2. Installation of the anti-capillary hydro isolation of the external and internal walls

Considered further constructive solutions of the building waterproofing are used on significant amount of the historical buildings in Saint-Petersburg. For example, the next variants of this type of works, which are made by LLC "Geoizol", are considered in the thesis:

- The Alexander Palace. Constructive solutions to the basement deepening and waterproofing (appendix 1, sheets 1-2).
- FGBUK "GMZ" Peterhof" Saint-Petersburg, Kolonistskyi Park, Olgin Island, lit. A. Restoration of the basement floor with installation of hydro isolation and drainage system (appendix 1, sheets 9-10).
- FGBUK "GMZ" Peterhof". Restoration of the socle floor of the Verhnesadskyi house, located at: Peterhof, Pravlenskaya Street, house 11 (appendix 1, sheet 11).

Complex of measures with using of the monolith reinforced concrete caisson and special hydro isolation materials on them, provides a reliable waterproofing system from the water under the hydrostatic pressure. But this system of measures does not prevent the water rising in the capillaries of the damaged foundations and walls. To prevent the capillarity water rising the anti-capillary waterproofing cutting is made.

Three types of the anti-capillary hydro isolation exist:

a. Installation of the anti-capillary hydro isolation under the pressure
b. Installation of the anti-capillary hydro isolation without pressure
c. Installation of the anti-capillary hydro isolation by using steel or plastic sheets
d. Technology of the anti-capillary hydro isolation by using horizontal membranes made of steel sheets.

a. Technology of the anti-capillary hydro isolation under the pressure:

General requirements

Anti-capillary hydro isolation is made in the brick walls of the basement floor by injection to the seams of the brick masonry of the water repellent silicone microemulsion Wacker-SMK 550. The necessity of the anti-capillary hydro isolation is determined by the place. Consumption of the undiluted emulsion is 2 kg on the 1 m^2 of the brick masonry cross section.

Drilling is carried out from both wall sides by ∅25 mm with step 125 mm. The thickness of the walls is specified during the production process by test drillings. The depth of the drilling hole is a half of the wall thickness plus 100 mm. The holes are placed in the mortar seam at an angle of 90° to the wall surface. Drilling of the holes and embedment of the cavities inside the wall by cement mortar are made by sections with length 5 meters via 5 meters. Leaved intermediate sections of the brick wall with length 5 meters, are drilled and filled by the mortar injecting in secondarily, after injecting of the first sections.

The order of the works

- Repairing of the brick masonry is made higher above the top of the projected reinforced concrete caisson by the cement-sand mortar with addition of the lime in an amount of 20% by weight of cement. Composition of the mineral part to the volume is cement/lime/sand (1: 0.2: 3), with water-cement ratio 0.4; sand module size is less than 2

- Embedment of the cavities inside the wall (1st injection):

  1) Cleaning of the drilling holes from the drilling dust by the blowing of compressed air and washing by water.
  2) The jetting to the drilling holes of the cement-sand mortar composition: lime/cement - 0.5, with water/solid materials ratio – 0.5.

Portland cement M400 D20	-	100 parts (by volume)
Hydrated lime	-	50 parts (by volume)
Water	-	75 liters

Jetting of the mortar is made in stages, the process starts from the extreme hole position with pressure until 0.2 MPa. Repeating of the holes drilling with ∅18mm can begin no earlier than after 4 hours after injection completing.

- Injecting by microemulsion (2^{nd} injection):
  - Cleaning of the holes from the drilling dust by the blowing of compressed air
  - Injecting of the mortar Wacker-SMK 550 under the pressure approximately 1 MPa. The injection should be continued until the injecting mortar does not begin to go beyond of the wall surface, and cover the half distance between the drilling holes. With this brick wall and seam becomes moist
  - Embedment of the drilling holes is carried out by the lime-cement mortar with admixtures of Wacker-SMK 550, which are diluted by water at a ratio of 1:18

b. Technology of the anti-capillary hydro isolation without pressure

Initially all the anti-capillary hydro isolation was performed on the technology without any pressure. In the masonry of the wall the holes are drilled. In them the injectors are inserted, they are connected to the small capacities, which are filled by the injecting mortar. Because of a low productivity, and small penetration ability, the technology "under pressure" was developed.

At present time the German company Remmers developed the technology of anti-capillary hydro isolation, which works without pressure, made of cream materials. The basis of all materials is "Sialn". Its latest generation is cream. It consists of cream and binder material. The principle of operation: waterproofing of the capillary pores of the brick masonry with the creation of the maximum water-repellent effect. When the cream is used on the masonry, the water is evaporated, then Silan comes to the gas state, easily comes to the pores, and their surface is covered by the cream. Cream reacts with the surface, as a result the insoluble compounds are created. Effectiveness of the hydro isolation is from 10 to 100 years. One advantage of this method is, that for the effective work it is enough to drill the horizontal holes ∅10mm in the masonry seams.

Application features: in the walls, which are water saturated on 50% is not necessary to dry the masonry before the works start. In the case of a high humidity of the wall, it is necessary to dry the masonry, for the possibility of the waterproofing.

c. Technology of the anti-capillary hydro isolation by using horizontal membranes.

In 2013 on Alexander Palace the variant of the horizontal hydro isolation between the walls and foundation made of corrugated plastic was developed. According to the project the walls from both sides, in stagger order must be sawn by the holes with thickness up to 0.5 cm. Into the holes the sheet of the corrugated plastic was inserted and embedment of the mortar under pressure was carried out. The operation was repeated in the lower part of the walls in stagger order after mortar strengthening. The method has not received a real realization because of high costs of the project.

In 1948 in restoration of the Great Palace in Peterhof the new method and the project of the walls waterproofing were developed. The idea of the method is that the lower part of the brick walls was sawn from the original masonry on the blocks in stagger order, and these blocks are replaced by the preliminary prepared concrete blocks with the same size 500x10x400 mm, which has preliminary installed hydro isolation on them. The method does not get a realization.

d. Technology of the anti-capillary hydro isolation by using horizontal membranes made of steel sheets.

This type of hydro isolation in Saint-Petersburg on the historical buildings practically is not used. The method is used in the construction of some new buildings. The idea of the method is that on the foundation top of is installed the hydro isolation, which are made of steel sheet with anchorage to the foundation body. Above this hydro isolation the brick masonry begins.

11.2.3. Installation of the outer vertical hydro isolation

Considered further constructive solutions of the building waterproofing are used on a significant amount of the historical buildings in Saint-Petersburg. The next variants of this type of works, which are made by LLC “Geoizol”, are considered in the thesis:

- The adaptation for contemporary usage of the building located at: Central District, Konyushennaya Square, house 1, lit. A, in a hotel complex (appendix 1, sheets 5-6).
- Saint-Petersburg, Isaac’s Square, house 9, Pochtamskaya Street, house 2. Complex waterproofing of the building and waterproofing of the basement floor.

Outer hydro isolation is a system, which works to the positive pressure. The following works must be implemented to install the outer hydro isolation system for an existing building:

- The digging works of the foundation to the project level
- Cleaning of the foundation
- Restoration of the foundation masonry
- Installation of the preparation layer for hydro isolation if it is necessary
- Application of the hydro isolation material
- Organizing of the drainage system
- Backfilling of the outer foundation part, without any damages to the applied hydro isolation and installed drainage system

On the restoration of the basement floor of the pavilion “Cameron Gallery” in the Catherine Park of Pushkin city, the works for the installation of the outer hydro isolation were carried out in the period of the positive air temperatures. Works were carried out part by part, in bad weather periods temporary canopies were installed. After digging works (see figure 11.6) were fixed a significant amount of the rubble foundation damages, damages of the abutting pilasters and pylons, the seams of the rubble foundation are destroyed by the water, mortar in the seams are destructed. In the zone of the works were electrical cables, which required protection and fastening. Also in the foundation masonry were fixed profiled elements made of tufa, which needed the conservation.

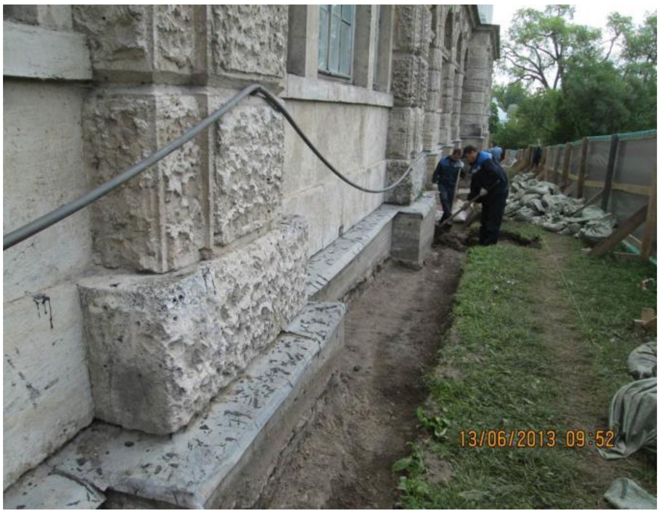

Figure 11.6 Phased digging of soil along the building

In addition, after detailed examination of the socle state has revealed that it is necessary to make the works for socle covering cleaning from the overgrown green moss to the height 130 cm and restoration of the covering slabs of the abutting foundation parts.

Works after the digging works of the foundation to the project level were carried out in the next sequence: hydro dynamic cleaning of the foundation surfaces, pointing and embedment of the rubble foundation seams with replacement of the destructed bricks, using of the special plastering Vandex Uni Mortar, waterproofing of the vertical and horizontal foundation surfaces by Vandex BB 75 and backfilling layer by layer with earth rammer in the following way:

From the outer part of foundation the hydro isolation are carried out in the connection of the places of the wall masonry and rubble foundation masonry by Vandex BB 75 in two layers.

Before the application of the hydro isolation covering it is necessary to complete the following types of works:

- Pointing and embedment of the brick and rubble masonry seams by Renovir Bricks
- Punching of the gab on the whole building perimeter on the connection of brick wall masonry and rubble masonry. Gab is punched by perforator

with pike. The minimum size is 30x30 mm, the maximum is 40x40 mm. Gab is cleaned by the compressed air and water under the pressure. Example of this processes see figure 11.7. Cleaned gab is filled by repairing mixture CRS RM 05.

- Waterproofing plastering on the net Alit GR-1n in two layers (t = 20 mm).
- Covering of the socle (blocks made of sawn limestone) is necessary to process by the water – repellent impregnation of Funcosil WS (figure 11.8).

Figure 11.7 Restoration process of rubble foundation masonry. Punching and embedment of the masonry seams

Figure 11.8 Application of waterproofing covering

11.2.4. Installation of the inner hydro isolation

In the difficult soil conditions of Saint-Petersburg and because of high level of groundwater for the historical buildings in the installation of the monolith reinforced concrete caisson, using only the concrete with high grade of waterproof is not enough to create effective hydro isolation. Because of that with installation of the reinforced concrete caissons the additional complex of measures for waterproofing is used. One of these measures is the installation or application of the special hydro isolation materials to the surface of the reinforced concrete caisson. The following types of internal waterproofing exist:

1. Internal waterproofing plastering

The internal waterproofing plastering can be carried out in the following way. On the surface of the monolith hydro isolation reinforced concrete slabs a penetration waterproofing material is applied, for example – Vandex Super, in two layers. Interval between application of the first and the second layers is 30-50 minutes, it depends on the air temperature and humidity of the basement floor (1st layer should not solidify before application of the 2nd layer). Material consumption is 1,5 kg/m2.

Before the application of the material Vandex Super it is necessary to punching the gab to the work concreting seams size of 30x30 mm (as minimum). After cleaning of the gab by the compressed air under the pressure near 200 atmospheres, the embedment of the gab is carried out by dimensionally stable polymer-cement composition Vandex CRS RM 05.

In the corners of connection of the monolith slab with the brick wall the gab with size of 30x30 mm (as minimum) is punched. After cleaning of the gab by the compressed air under the pressure near 200 atmospheres, the embedment of the gab is carried out by dimensionally stable polymer-cement composition Vandex CRS RM 05. Then on the corner of the gab on its full length the stripe of the elastic waterproofing composition Vandex BB 75 is applied. On the brick walls above the reinforced concrete slab the material Vandex BB 75 is applied in two layers.

On the internal walls before the application of Vandex BB 75 it is necessary to make the pointing and embedment of the seams by the composition Vandex CRS RM 05 to the depth 20 mm to the level of 0.5 meters higher of the maximum level of the groundwater.

Application of the repair and waterproofing compositions is carried out to the moist, but not wet surface (presence of the flowing on the surface or stagnant water is unacceptable). After application of the materials it is necessary to protect the surface from fast drying (necessary to cover by met cloth, film, moisten if it is necessary). Care for the surface to produce during 3 days.

Works are implemented with temperature not lower than +5^{o}C

This decision was implemented in Saint-Petersburg, Nevskyi Avenue, house 48, lit. A. There were the works of the complex building structures of the basement floor protection from moisture and works for foundation strengthening.

Method of the installation of the waterproofing plastering on the prepared surface is highly effective. Many different materials exist, which are designed to provide the effective hydro isolation with correct exploitation. Materials, which LLC “Geoizol” used in the work production in the buildings reconstruction and waterproofing, are following:

- VANDEX BB 75 E. VANDEX BB 75 E – is a two-component cement-based with polymer admixtures for surface waterproofing. Coating does not fade, has hydrophobic properties, resistant to the water and moisture.

Field of usage

VANDEX BB 75 E is applied on the concrete, stone, and plastering surfaces, which require the protection from water and moisture. Because of elasticity the material can be used on the parts, where exist the possibility of cracking and deformation.

Because of content in the composition VANDEX BB 75 E of cement, quartz sand with graded particle size and special chemical admixtures, and also exactifying component, the covering is waterproof (tested at a pressure of 7 bars) and elastic. The material has ability to cover the cracks with width until 0.5 mm. Composition gets extremely high adhesion properties, both at the beginning and at the end of the setting period, because of that it is possible to use the material on the horizontal and vertical surfaces. Coating is durable, frost and heat resistant, and at the same time it is vapor-permeable. It provides a reliable protection from the carbon dioxide (CO_2).

VANDEX BB 75 E is not a decorative material.

- VANDEX SUPER. VANDEX SUPER is the material of penetrate action, which is used on the concrete surfaces and provides surface protection and waterproofing. Consists of grey and white portland cement, specially treated quartz sands and chemically active substances.

Field of usage

VANDEX SUPER can be used for any structurally strong concrete: new or old. The material can be used from the side, which is under pressure, as well as from the opposite side. Typical fields of usage:

- Retaining walls, foundations
- Concrete slabs (floors, overlaps, wastewater treatment plants, balconies and others).
- Channels
- Structure seams
- Bridges
- Tanks for water storage

When VANDEX SUPER is used on concrete, chemically active substances penetrate in the materials pores and capillaries and react with the free lime and moisture. In the capillary system the insoluble crystal compounds are created and they eliminate the possibility of the water infiltration (even under the pressure). With this waterproofing coating is vapor permeable. VANDEX SUPER provides the waterproofing and protection of concrete from the sea water, waste water and aggressive groundwater, some of the chemical solutions. VANDEX SUPER can be used in the direct contact with the drinking water and can be used as a waterproofing and protection of the water storage tank, water towers, etc. VANDEX SUPER and VANDEX SUPER WHITE are not decorative materials.

2. Bitumen – polymer composition

Liquid waterproofing membranes are the composition, which is based on the solvent, and which contains the base – urethane, rubber, plastic, polymeric bitumen and their combinations. They are applied in the liquid state and solidified with the formation of the seamless sheet.

One material of this type is highly elastic polymeric bitumen coating the mastic Bitflex. Mastic Bitflex is a softly elastic durable material for hydro isolation of the basement floor external walls, foundations and reservoirs, which is necessary to the protection of structures from the groundwater under the pressure. Waterproofing mass Bitflex is applied to the stable base made of concrete, gas concrete, plastering, and stone masonry. After drying the coating becomes stable to the naturally created substances, which destroys concrete.

Bitflex is a one-component waterproofing mass based on the bitumen emulsion improved by the polymers without solvents and fillers. Because of thixotropic properties Bitflex can be applied to the vertical surfaces by brushes, roller or spray. After drying the Bitflex is transformed into a seamless, highly elastic film. After completely drying coating is not aging, covers newly formed cracks, waterproofing, gets frost and high temperature resistance, is stable to the naturally created aggressive substances.

Works production with this mixture in the complex of waterproofing works of the apartment house basement floor, which are located at Galernaya Street, 19 (appendix 1, sheets 3-4) are carried out in the following way:

1. Firstly the hydro jet cleaning of the surfaces of the brick or rubble wall masonry and existing reinforced concrete slab is carried out
2. The seams of the brick and rubble masonry are filled by the repairing composition Renovir Bricks
3. Surfaces of the brick masonry are made in the one surface level by the cement composition Alit GR-1 thickness 20 mm (same for rubble masonry)
4. Bitflex with plastic net with steps 4x4 mm is applied to the vertical and horizontal surfaces
5. On the top of the waterproofing the retaining reinforced concrete slab is made with thickness 100 mm

Instead of bitumen-polymer composition the polymer in combination with highly dense polymer-elastic membrane CEMproof SilverSeal „active" can be used. SilverSeal is a light weight, swelling, which reacts with water, sealing membrane. CEMproof SilverSeal is used in all cases where protection of the structures from the groundwater and sewage water is needed: hydro isolation of the foundations, basements, tunnels, garages, flat roofs and in other cases (see figure 11.9). Material has absorption capacity of a big amount of water, and good swelling capacity and sealing because of integrated highly swellable absorbent polymer. This material is able to bear the hydro static pressure until 2.5 bars. The water stability (alkaline water, salt water, etc.) does not cause any critical impact to the water penetration in longitudinal direction and through swelling nonwovens materials SilverSeal.

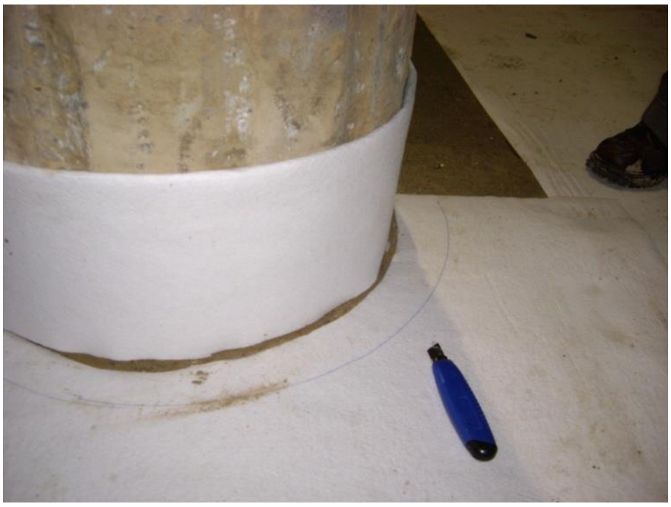

Figure 11.9 Membrane SilverSeal

3. Installation of the steel waterproofing

Another type of the internal hydro isolation is the installation of the steel waterproofing. Works production of the hydro isolation installation begins at the beginning of the installation of the reinforced concrete caissons.

Before the installation works start, it is necessary to prepare the walls surfaces before installation of the reinforced concrete foundation enlargement. In the presence of the friable masonry parts of the external wall, it is necessary to remove all these parts to the depth of 2-3 cm. Firstly the masonry surface is cleaned from the friable parts and dust by compressed air, then the surfaces are washed by water. Masonry seams are filled by repairing cement-sand mortar M75 with the addition of lime in an amount of 20% by the weight of cement.

It is also necessary to produce the anti-corrosion treatment of the caisson steel surfaces. According to the project, before the installation of the caisson foundation enlargements, their metal surfaces are treated by anti-corrosion composition, for example by “Zinga”, which is a one-component system, which consists of pure ready for using zinc powder.

Installation of the metal waterproofing is carried out with a gap of 30-70 mm from the vertical surfaces of the existing walls, with this the lower part of the metal sheets is installed to the concrete slab on 100 mm. Before installation of the metal sheets in project position it is necessary to drill the holes in them:

- D16-18 mm with 500 mm step holes in stagger order – for mounting of the steel sheets to the walls by using anchors
- D20 mm with 1000 mm step holes in stagger order for installation of the injectors for filling or flowrate of the repairing composition “Geolite Magma”

To make a fixation of the injection system pipes “Geoizol IS” to the metal sheets with 200 mm step the steel armature D3-4 is welded to the sheets, which is beaded in montage of the injection system pipes. For sealing of the steel with concrete connection the inject system is mounted with its next flowrate by the acrylate resin. Montage of the system is carried out after installation of the reinforced concrete foundation enlargement to the project position.

The system consists of liner injector (hose) and components. Hose is a polyvinyl chloride (PVC) pipe with D12 mm with holes for the injection of the resins, which provides the unhindered access for injecting composition.

After installation of the inject system the concreting of the slab foundation is made.

11.2.5. Installation of the external hydro isolation barriers

External barriers of waterproofing is carried out in two types: as the barriers made of clay lock and hydro isolation materials based on the clay, and installation of the barriers waterproofing by using the acrylate gel.

1. Clay lock

Clay lock is a historical type of hydro isolation, which was used in the construction of important buildings. This hydro isolation was used for the foundation walls, as well as for the floors of the basement floor. Installation of the clay lock is laborious:

- The first difficulty arises in the preparation of the material to the kneading: clay is necessary to soak, or affect by the freezing – thawing for the destruction of the structure with following soaking.
- The laying of the clay requires a big amount of manual labor, with direct installation of the clay locks manually, also with using of the power tools.
- For works implementation a significant amount of time is required.
- Clay lock is very difficult in a high quality of implementation, because for its production is required only the pure clay and inadmissible any admixtures.
- Clay lock can be used only with constant flooding of the structures by the groundwater, in the absence of water the clay dries, cracks, loses waterproofing properties.

Advantages:

- In quality implemented waterproofing clay lock provides the reliable protection of all structures from the all types of moisture
- Clay lock does not influenced from the foundation deformations

2. Hydro isolation based on the clay materials

Because of a high difficulty of the implementation of the clay locks, but the effectiveness of the hydro isolation based on clay, the bentonite mats and cords are developed.

Clay, which is applied in the dry state, in contact with water swells and becomes waterproof. Clay can be swollen on 10-15% in the maximum humidification compared to its dry state. Bentonite clay is an excellent waterproofing material, which for successful using needs correct hydration. Clay systems can be applied in the different construction phases. They can be installed before concreting, by gluing of the material to the support systems in the pits and in the foundations. One type of waterproofing is a waterproofing by bentonite mats. In the systems based on bentonite mats the clay is applied to the textile with consumption 5 kg/m^2. This solution provides easiness of the system installation.

Disadvantages of hydro isolation by bentonite mats:

- All disadvantages of the clay locks
- Using of the bentonite mats in the conditions of variable level of the groundwater is inadmissible. Mats are effective only at constant flooding. Variable level of the groundwater scours the clay, and clay lock comes to the emergency state.
- Usage of the bentonite mats in the socle level and below it is inadmissible, because with clay over drying occurs fast destruction of the bentonite mats.

3. Installation of the hydro isolation barrier by injecting of clay mortar. (Marley Palace, Peterhof, LLC “Geoizol”).

On the contour of the building in the stagger order on the width of 2 meters from the foundations the holes D 70-100 mm was drilled to the depth of the water impenetrable layer, which is located no more than on 2 meters from the ground surface level. In the bore holes the clay mortar under the pressure was injected. In this way hydro isolation of the foundation structures, basement floor of Marley Palace, which is located on an island surrounded on all sides by water, from the groundwater, was implemented.

4. Installation of the hydro isolation barrier by acrylate gel.

In difficult soil conditions and necessity of building waterproofing and the impossibility of its implementation in other ways, the method of creation of hydro isolation membrane by injecting of the acrylate gel through the foundation body and floor slabs to outside, is used. Acrylate gel from the external side of foundation creates the connections with soil and reacts with water. In this process the hydro isolation system to the positive water pressure is created.

Disadvantages of the method:

- Load bearing structures are damaged by a big amount of drilling holes;
- There is no possibility to control the continuity of formed waterproofing membrane;
- In case of presence of any cavities from the external foundation side (cable channels, wells, reservoirs, etc.), there is inevitably a huge

consumption of the expensive material. The method can not be economic, because it is used in exceptional cases.

11.2.6. Sanitizing plastering

The considered further constructive solutions of the building waterproofing are used on a significant amount of the historical buildings in Saint-Petersburg. The following variants of this type of works, which are made by LLC “Geoizol”, are considered in the thesis:

- The Alexander Palace. Constructive solutions to the basement deepening and waterproofing (appendix 1, sheets 1-2).
- Saint-Petersburg, Galernaya Street, house 19; Anglyiskaya Embankment, house 20, Zamyatin Lane., house 2. Basement waterproofing (appendix 1, sheets 3-4).
- The adaptation for contemporary usage of the building located at: Central District, Konyushennaya Square, house 1, lit. A, in a hotel complex (appendix 1, sheets 5-6).
- Saint-Petersburg, Mayakovskyi Street, house 36-38. Apartments redesigning for offices of CJSC “Pilon” (appendix 1, sheets 7-8).
- FGBUK “GMZ” Peterhof” Saint-Petersburg, Kolonistskyi Park, Olgin Island, lit. A. Restoration of the basement floor with installation of hydro isolation and drainage system (appendix 1, sheets 9-10).
- FGBUK “GMZ” Peterhof”. Restoration of the socle floor of the Verhnesadskyi house, located at: Peterhof, Pravlenskaya Street, house 11 (appendix 1, sheet 11).
- Saint-Petersburg, Isaac’s Square, house 9, Pochtamskaya Street, house 2. Complex waterproofing of the building and waterproofing of the basement floor.
- Deepening and waterproofing of the basement floor of cultural heritage building at address: Saint-Petersburg, Nevskyi Avenue, house 58.
- Saint-Petersburg, Nevskyi Avenue, house 48, lit. A. Complex building structures of the basement floor protection from moisture and foundation strengthening.

Sanitizing plastering is a wall protection from the salts. Chapter 6 contains the information about influences of the salts and water to the structures. Water, when soaking the foundation or walls masonry, leaches the salts from the masonry mortar. Binding materials consist of salts $CaCO_2$, AL_2O_3, SiO_2. When these materials come to the masonry seams, during drying their crystallization with expansion in 400-1000 times happens into the pores of the materials, and then the structure of material is destructed.

Visually the salt leaching appears as salt efflorescence. In the historical buildings, even with building restoration of the damaged hydro isolation of the wall, in which moisture does not come into the structure, the walls can keep the old moisture. And with gradual drying of the walls the salts will also be allocated and deposited on the wall surface. Good example of it is shown in figure 11.10.

Figure 11.10 Soaking of the brick masonry vault because of waterproofing malfunction of terrace

To provide the complex waterproofing protection of the brick walls, in the end of the works for reconstruction of the foundation waterproofing, often the necessity to protect the basement floor rooms from the water and salts allocations is occurred. The same problem of water penetration to the brick masonry in the case of impossibility of the structure waterproofing in any other way is solved by the application of the sanitizing plastering. Sanitizing plastering provides the protection of the basement floor rooms from the water and salt allocations.

Sanitizing plastering has a great porosity and resistance to the salts. Plastering is carried out in two layers, thickness no less than 20 mm. The first layer is needed for taking of the capillarity moisture, in the layer goes the evaporation of moisture. The second layer has water-repellent properties and repels the moisture. In this layer the crystallization of the salts happens. Sanitizing plastering lifetime in these conditions up to 20 times is higher than for normal plastering. With time, as the saturation of the second outer layer by salts rises, gradual destruction of the plastering from outside to inside is occurred. When the process gets the intensive development, plastering is replaced.

11.2.7 Waterproofing of the engineering networks entrances

This question is important, because in the modern buildings the execution of the holes for the engineering networks is inevitable: heating systems, water supply system, sewage, electric networks. Complexity of the question is, that for the entrances holes have to be executed below the ground freezing depth, but in the conditions of Saint-Petersburg, the entrance holes have to be below the maximum groundwater level. Without the hydro isolation of the entrances, impoundments of the basement floor are inevitable by the groundwater. One part of the question is the restoration and renewing of the damaged foundation masonry before installation of the entrances for the networks.

Holes for the system entrances in the existing foundation have to be marked out, the foundation have to be reinforced, and after that it is possible to make the holes in the foundation. They can be made by punching or by drilling. The holes in the rabble foundation are concreted with installation of the embedded items with flanges made of metal.

With passing through the hydro isolation of pipes, cables, anchors, etc. it is necessary to provide the installation of the embedded items with flanges or the sealing flanges welded to the passed items. Embedded items are usually made of the pipes with diameter higher than the diameter of the passed item, and flanges with width less than 12 cm have to be welded so, that their external surface has to be situated in the plain of the hydro isolation layer. Connection of the flanges with hydro isolation, as well as the sealing of the free spaces in the embedded items should be provided, in accordance with the accepted type of waterproofing. For capillary moisture hydro isolation for passing of the pipes, cables, anchors and etc., is possible to use simpler solutions (see figure 11.11).

Figure 11.12 shows is more difficult example of this type of connection. With passing of the hot pipes through asphalt, bitumen and plastic hydro isolations it is necessary to provide the heat insulation of the hydro isolation materials. (CN 301-65, 1.20).

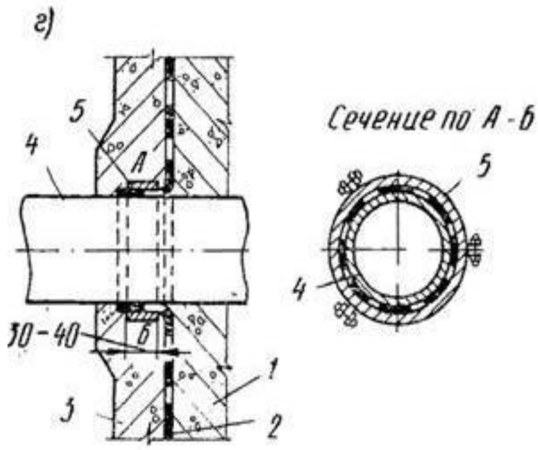

Figure 11.11

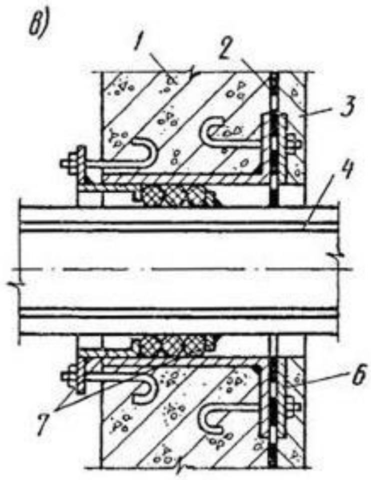

Figure 11.12

LLC “Geoizol” develops the entrance junction of the networks systems through the foundation body. Example of implementation of this type of works see the adaptation for contemporary usage of the building located at: Central District, Konyushennaya Square, house 1, lit. A, in a hotel complex (appendix 1, sheets 5-6).

Description

Initially to pass the networks through the foundation body the entrance hole with necessary diameter is drilled or punched, then the sleeve with necessary diameter and length is installed. The sleeve is needed for protection of the networks pipes and cables from the pressure of the weight of the situated higher entrance-hole structures. Depending on the type of the entrance structure the sleeves with different types of mounting can be used. In the end of installation of the sleeve, the formed hole around is concreted, after installation of waterproof self-expanded cord Besaplast. From the outer foundation part in the zone of entrance the additional layers of the hydro isolation are applied to protect the foundation structures from possible leaks. In the zone of connection area of hydro isolation and sleeve body the pressure-exerting flanges are used to provide the sealing of the created seam. To ensure the entrance leakproofness inside the sleeve the sealing cord with sealing pugging around the entrance structure is installed. In the end of the works backfilling of the structures is performed.

12 CONCLUSION

The thesis considered hydrogeological conditions of Saint-Petersburg, questions of implementation and installation of building waterproofing, technical state of hydro isolation of the historical buildings and possible variants of waterproofing reconstruction.

Reasons of hydro isolation reconstruction

Reasons of hydro isolation reconstruction		
Reasons	Types	Annotation
Reconstruction of previously existing waterproofing structures	Total destruction of the hydro isolation materials after long exploitation period	Limestone of socle
		Horizontal and vertical hydro isolation
		Waterfall installations
	Damages of existing hydro isolation during building exploitation	Anti-capillary hydro isolation
Waterproofing reconstruction as necessary part of the works in total building reconstruction	Creation of a new basement floor rooms	In buildings without any basement
	Changes of purposes of existing basement rooms	Transformation of unexploited rooms to exploited rooms
	Improving of working conditions in basement floor rooms	Creation of necessary temperature-humidity regime
	Reducing of exploitation costs of the building	On repairing of damaged structures
		On repairing of broken equipment
		On water pumping
Changes of exploitation conditions of the building or its parts	Flooding of the basement floor rooms by water	Technogenic water
		Groundwater
		Atmospheric water
	Developing of destructions by moisture of the building structures	Corrosions of the steel structures
		Rooting of the wooden structures
		Destruction of concrete
		Destruction of the walls plastering
		Destruction of the painting layer
	Increasing of humidity in the rooms	

Destruction of the hydro isolation materials under the impact of changes of environment conditions	New aggressive impacts	Chemical substances
		Dynamical conditions
	Changes of the groundwater level	Rising or lowering
	Changes of the ground surface level	Rising or lowering

Reasons of hydro isolation reconstruction

From the listed earlier reasons the main ones are: absence of hydro isolation of the structures of historical buildings and necessity of using of the underground spaces of existing buildings in the difficult conditions of megalopolis.

Ways of waterproofing reconstruction

Ways of the hydro isolation reconstruction:	Reconstruction of integrity of existing damaged structures	Embedment of the cracks and structural damages
		Reconstruction of damaged external vertical hydro isolation of the foundations
		Reconstruction of the waterproofing properties of the socle made of limestone, by recovering of integrity and hydrophobisation of the socle surfaces
		Recovering of waterproofing properties of damaged blind area
		Recovering of the damaged hydro isolation of the networks entrances
		Improving of the water-repellent properties of surfaces, by impregnation by hydrophobisation composition
	Creation of the new waterproofing structures made of modern materials	Installation of horizontal hydro isolation between the walls and foundations by using of anti-capillary hydro isolation in the lower wall masonry layer
		Installation of the sanitizing plastering inside the rooms
		Installation of hydro isolation of the networks entrances
		Placement of the water drainage: main cornice, window-sill shimmer, secondary cornice and others
		Recovering of the floor and wall hydro isolation of the basement floor by installation of monolith reinforced concrete caisson
		Usage of the new modern materials and technologies for creation of effective waterproofing of the structures

The complexity of the historical building structure waterproofing, in contrast to new construction is stipulated by the following factors:

- Necessity to take into account the technical condition of the existing structures, exploited in difficult conditions, have received numerous damages
- Necessity to find out the peculiarities of impact on the existing structures of harmful natural conditions: aggressive groundwater, ecological factors, soil conditions
- Necessity to find out the peculiarities of impact on the existing factors of harmful techno genic conditions: technogenical processes, different types of dynamical impacts, influences of neighboring structure construction, influences of harmful manufacturing and others
- Necessity to take into account the possibility of combined work in the structures of different materials. Thoughtless decision to use the modern materials can lead to the destruction of historical buildings
- Necessity to preserve the historical building appearance with using of the modern technologies
- Periodically occurs the necessity to implement the difficult modern solutions in the conditions of full preservation of historical buildings, for example, underground parking construction on 1-3 floors below the ground surface level inside of the building in dense urban area

The thesis analyzed the project solutions of recovering of historical buildings waterproofing. The information is taken from experience of leading organizations in Saint-Petersburg. With new materials and technologies the new possibilities of effective hydro isolation protection of historical buildings are created. This question constantly develops, new solutions of the problems appear. Waterproofing materials constantly improve, become more reliable and durable. Today the new specialists in the area with higher qualification are required. The question of waterproofing is actual at the real time, for it is necessary to find the new solutions on every object and on all historical buildings. The reliability and durability of the structures depends on the correct solutions of these questions.

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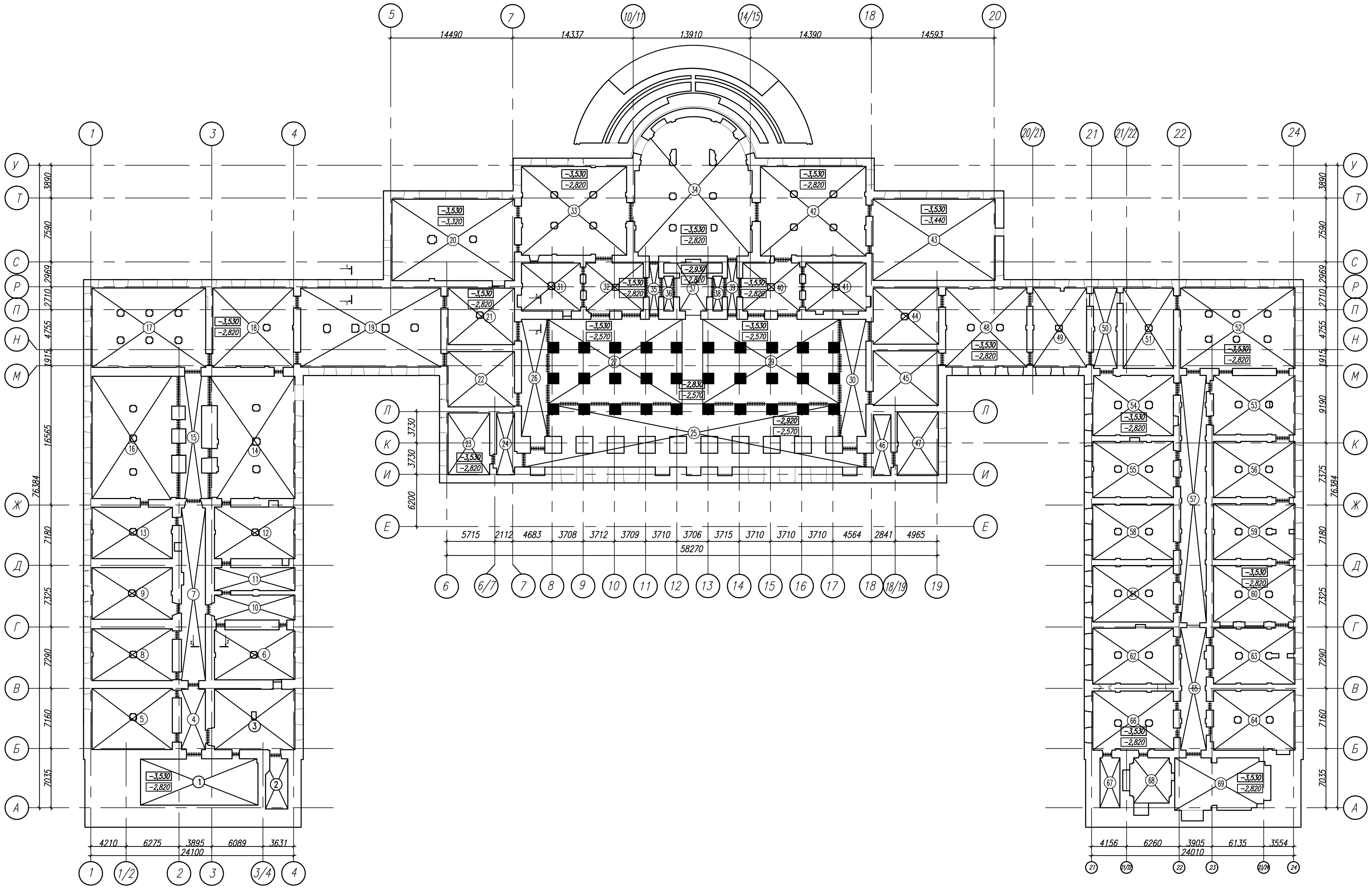
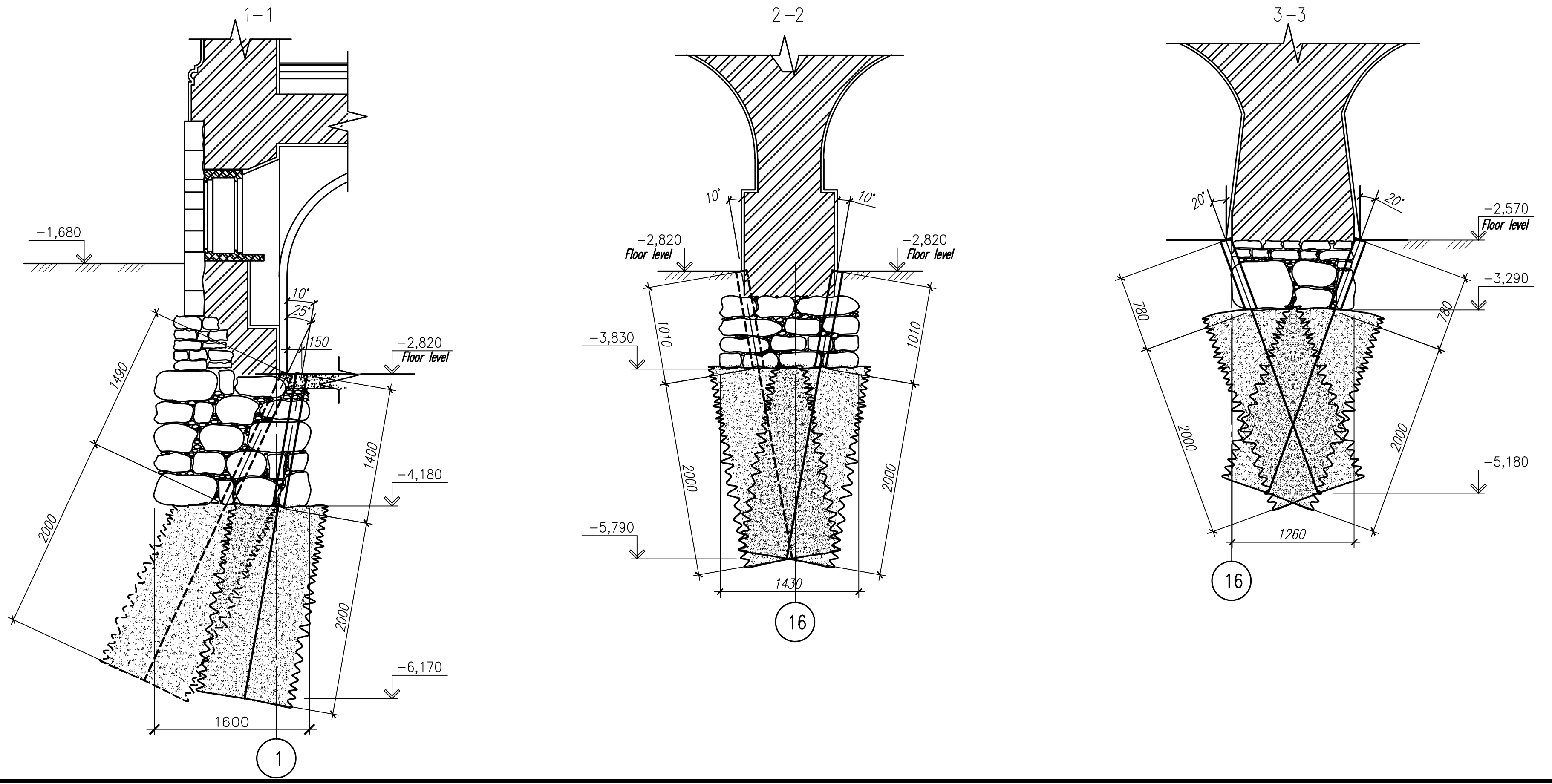
Appendix 1. Projects of buildings waterproofing, provided by LCC “Geoizol”

The scheme of reinforcement of concrete caisson



Cementation of the foundation body and contact zone "foundation–soil"



1. The socle top of the building is the relative level 0,000, it corresponds to an absolute mark of the Baltic height system +65,8 meters.
2. Under plate of caisson execute the preparation of rubble, rammed into the ground (80mm), 2 layers of polyethylene film, cement–sand stainer (50 mm).
3. Before the start of the waterproofing works, dismantle all temporary walls, dismantle the floors, to dig out the ground to design level, complete all works, which are provided before the waterproofing works

Conventional designation

1.400 – design level of the caisson top surfaces

1.530 – existing level of the basement floor

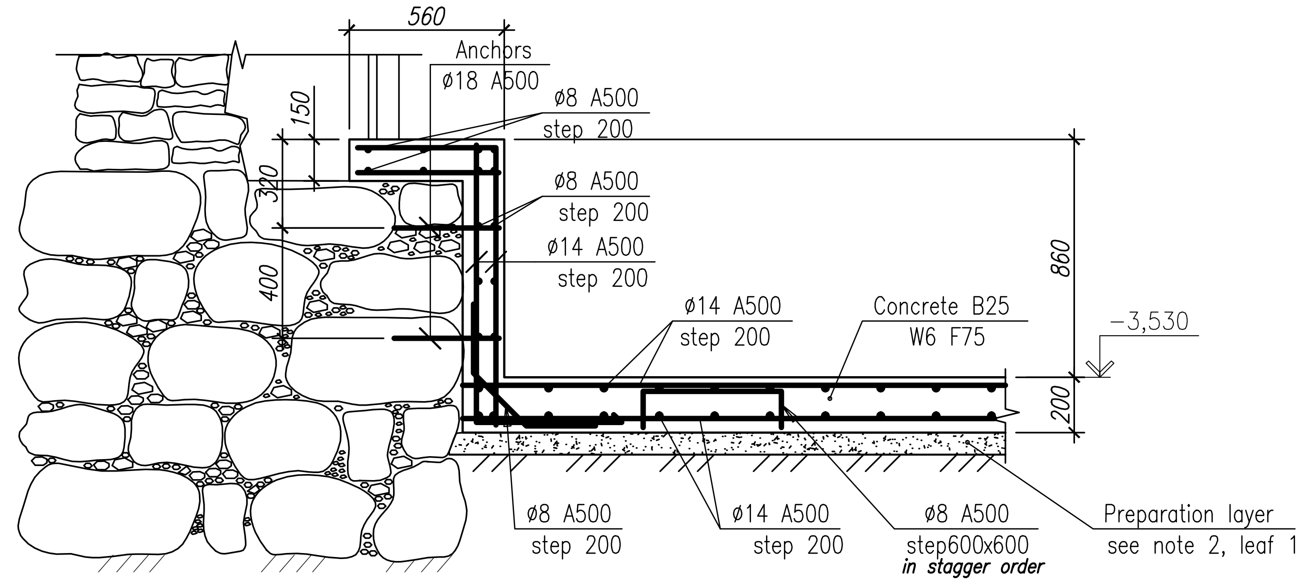
(7) –section of concreting and its number

–connection of the concreting sections

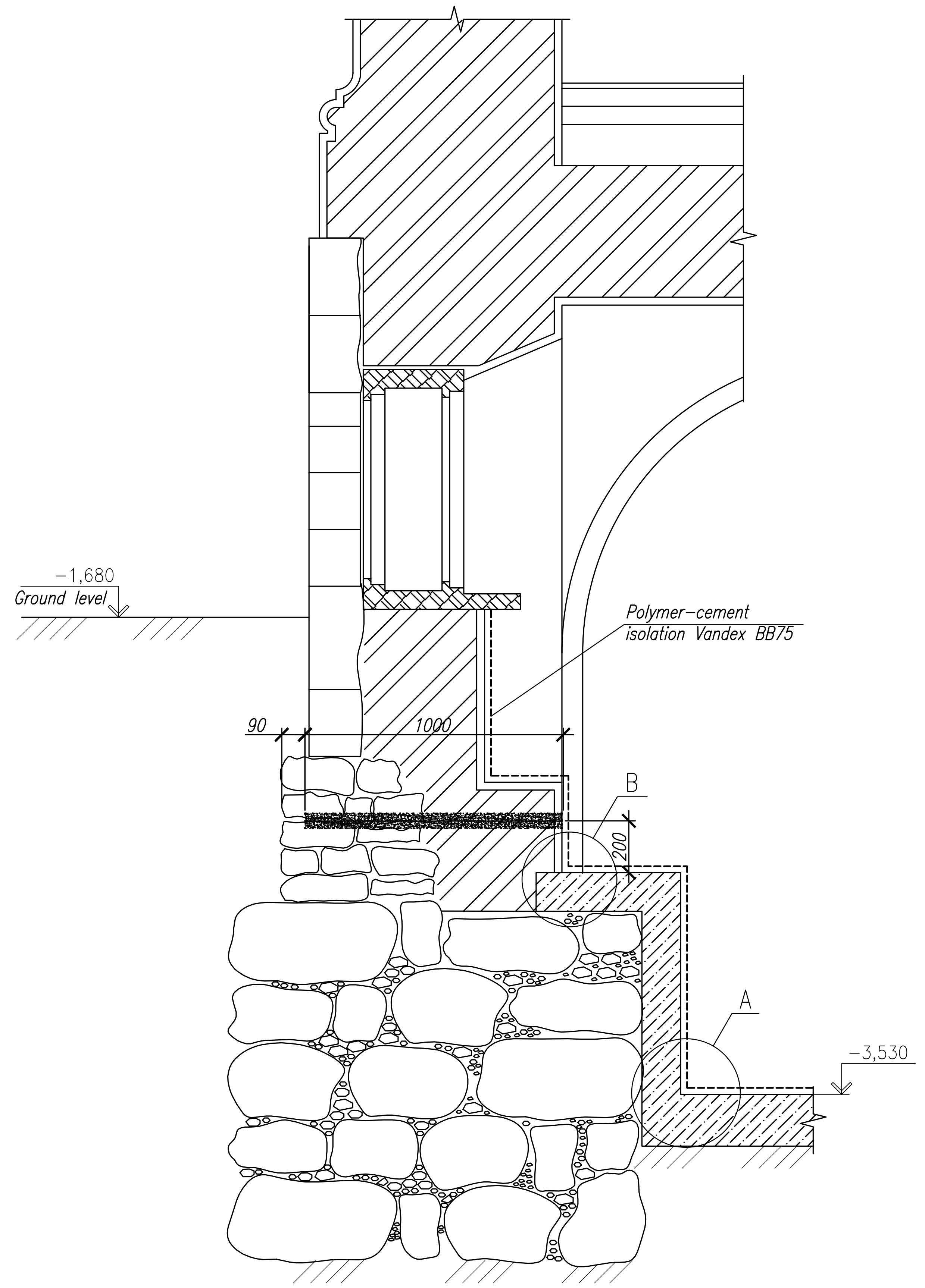
Changes	Partic.	List	№ doc.	Sign.	Date	Reconstruction, restoration, technical re-equipment and the adaptation of the Alexander Palace for museum usage by the address: Saint–Petersburg, Pushkin city, Dvorcovaya Street, house 2			
Developed		Fedorov			2015	Alexander Palace. Construction solutions for basement floor deepening and waterproofing	Stage	Sheet	Sheets
							P	1	11
						Scheme of reinforcement of concrete caisson. Cementation of the foundation body and contact zone "Foundation–Soil"	ООО ГЕОИЗОЛ		

Size A2

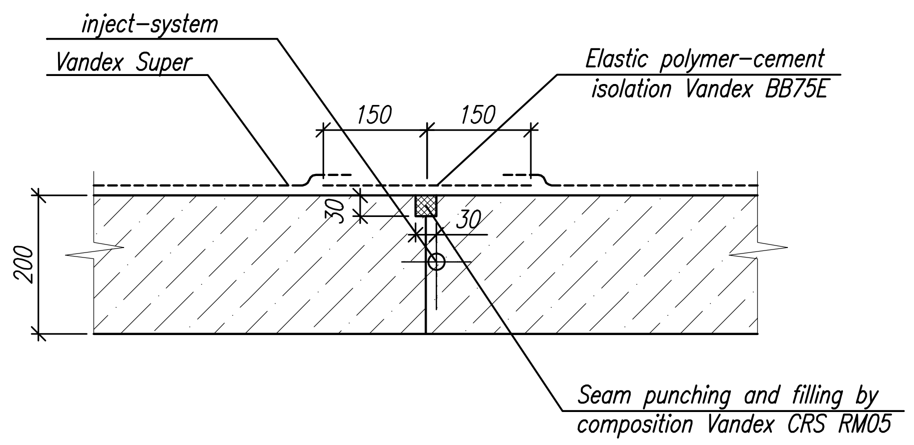
Scheme of reinforcement of the concrete caisson



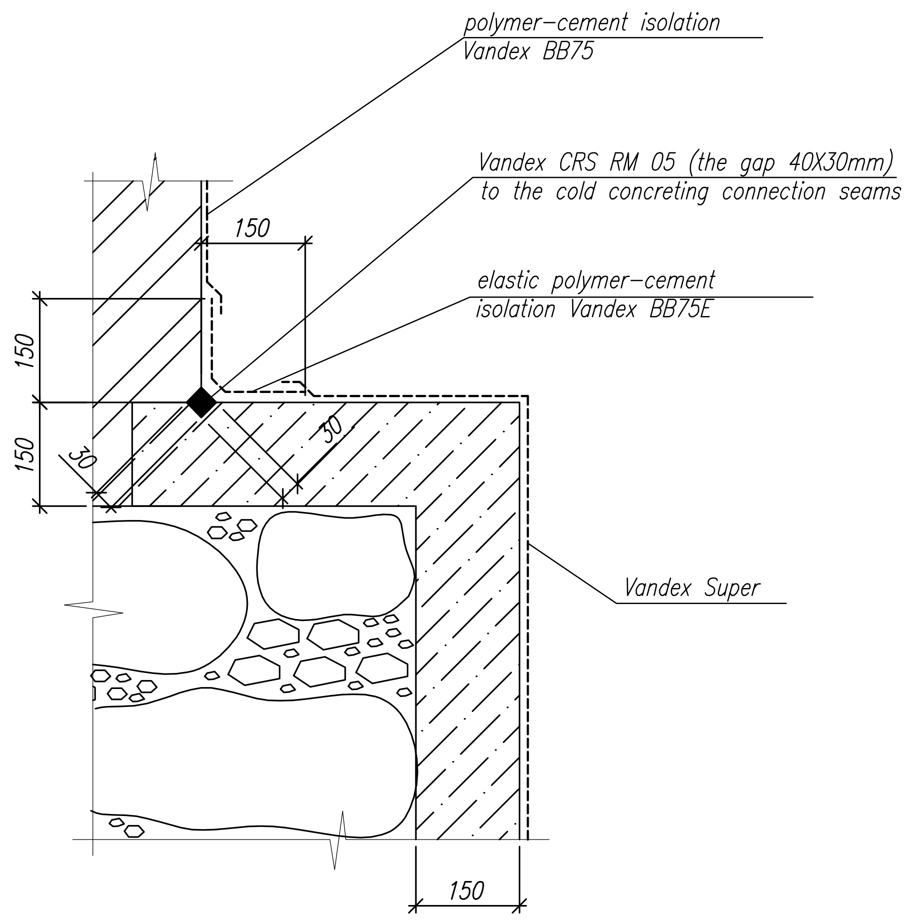
Installation of anti-capillary hydro isolation



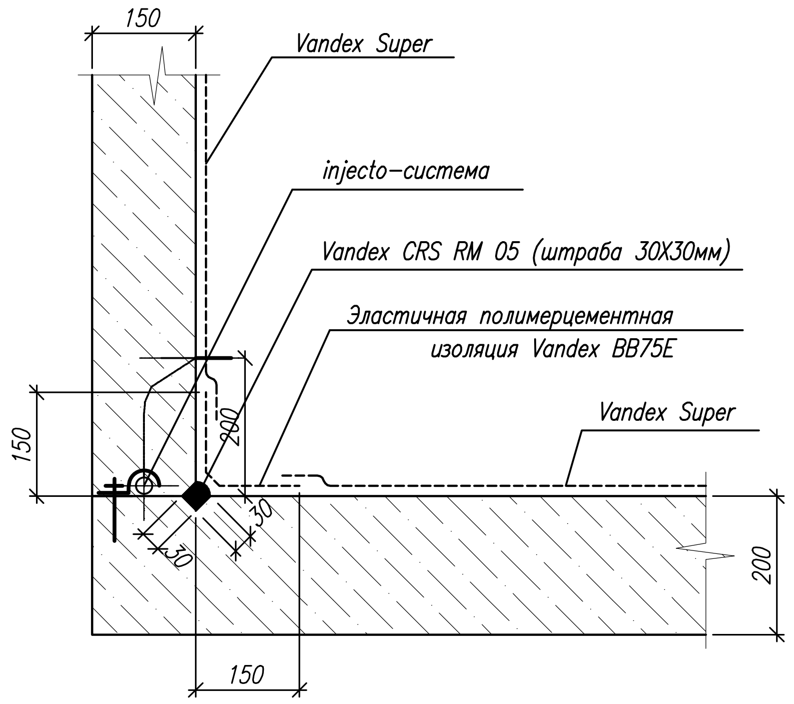
Installation schemes of the concreting connection seams



Junction B



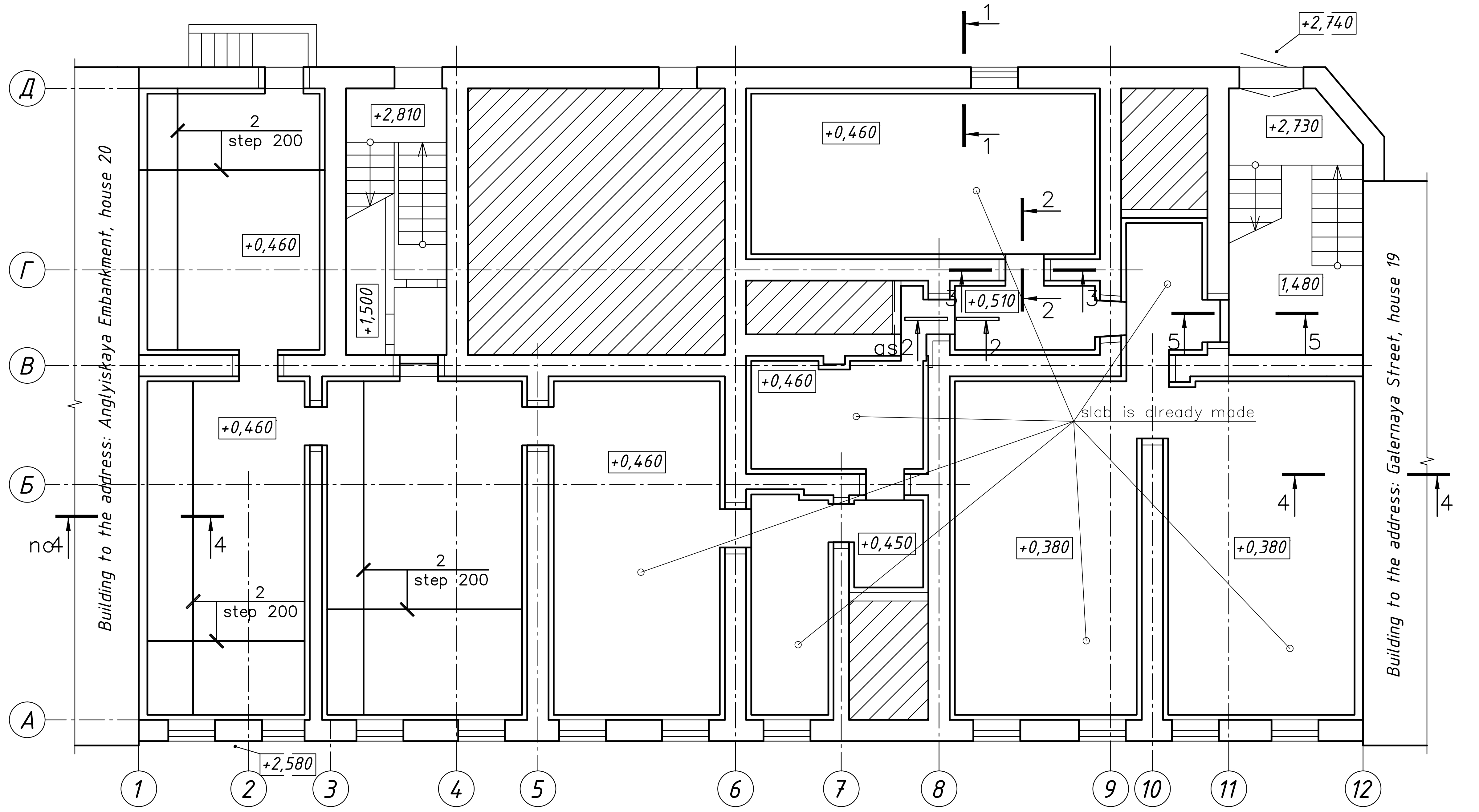
Junction A



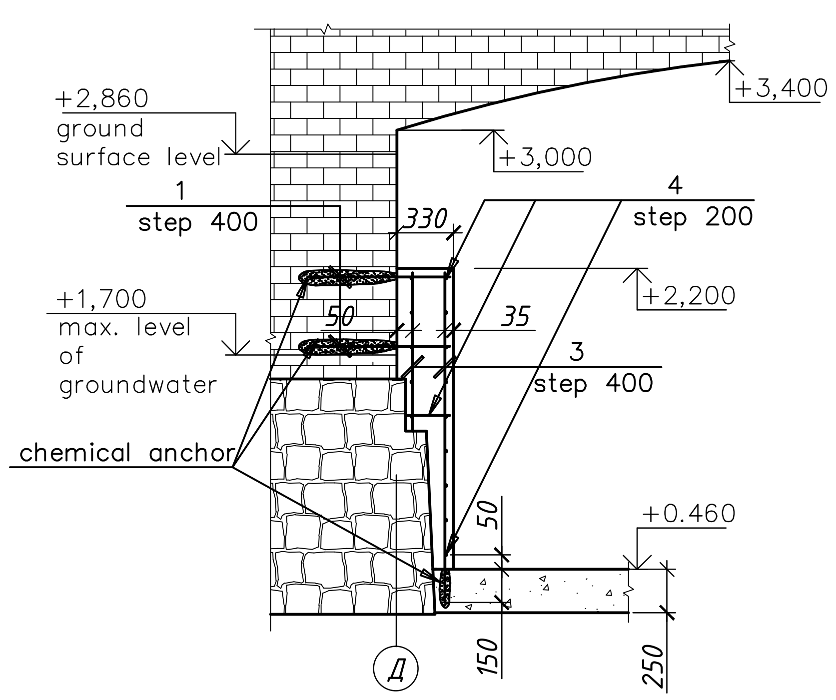
Changes	Partic.	List	№ doc.	Sign.	Date	Reconstruction, restoration, technical re-equipment and the adaptation of the Alexander Palace for museum usage by the address: Saint-Petersburg, Pushkin city, Dvorcovaya Street, house 2			
Developed		Fedorov			2015	Alexander Palace. Construction solutions for basement floor deepening and waterproofing	Stage	Sheet	Sheets
							P	2	11
						Installation of anti-capillary hydro isolation. Installation schemes of the concreting connection seams. Scheme of reinforcement of the concrete caisson.	ООО ГЕОИЗОЛ		

Size A2

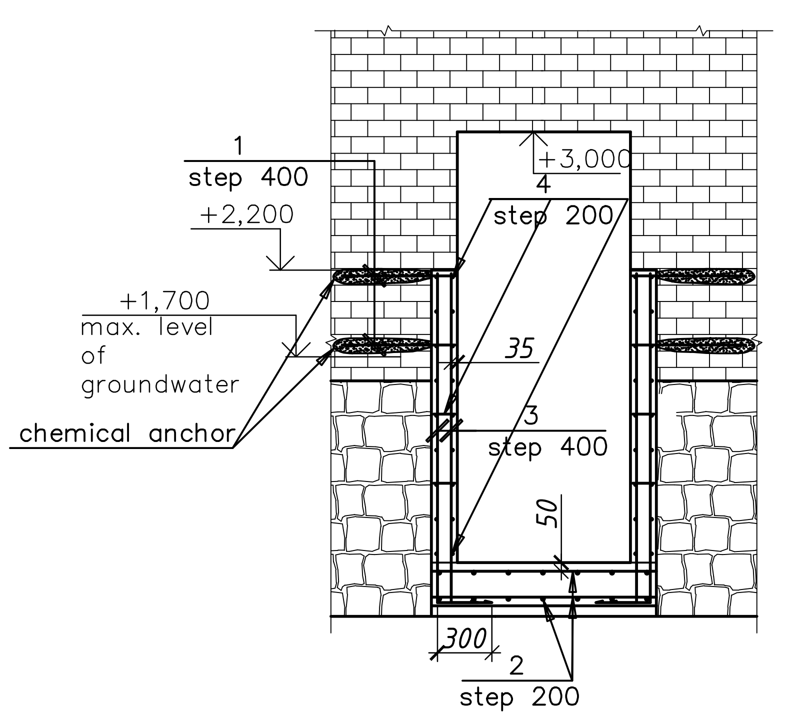
Scheme of reinforcement of foundation slab



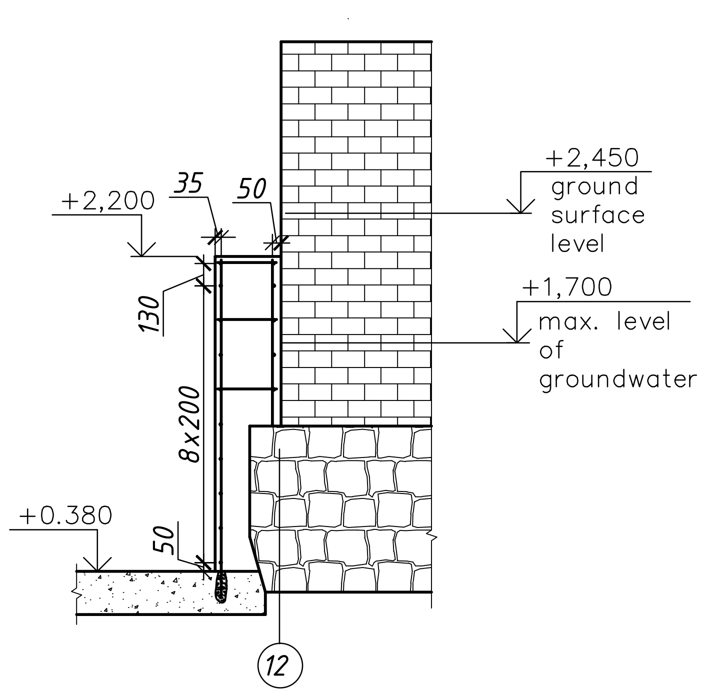
1–1



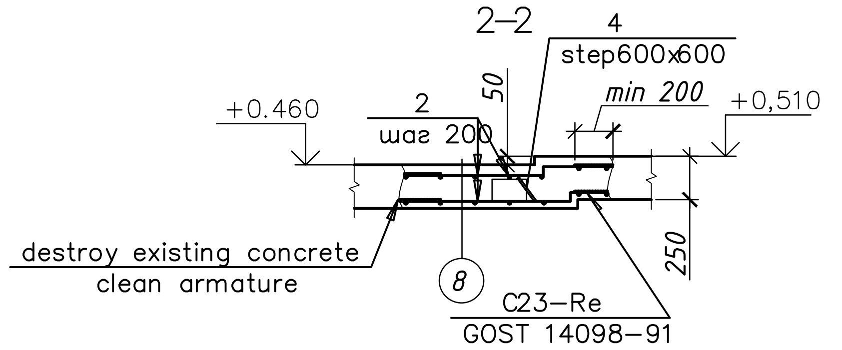
3–3



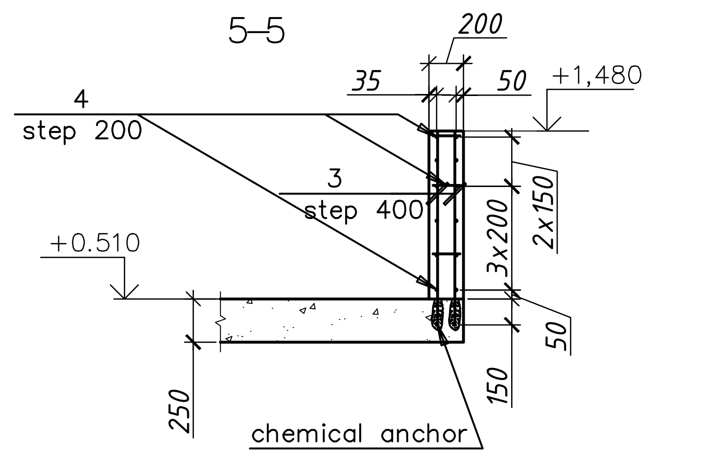
4–4



2–2



5–5



Specification for monolith structures

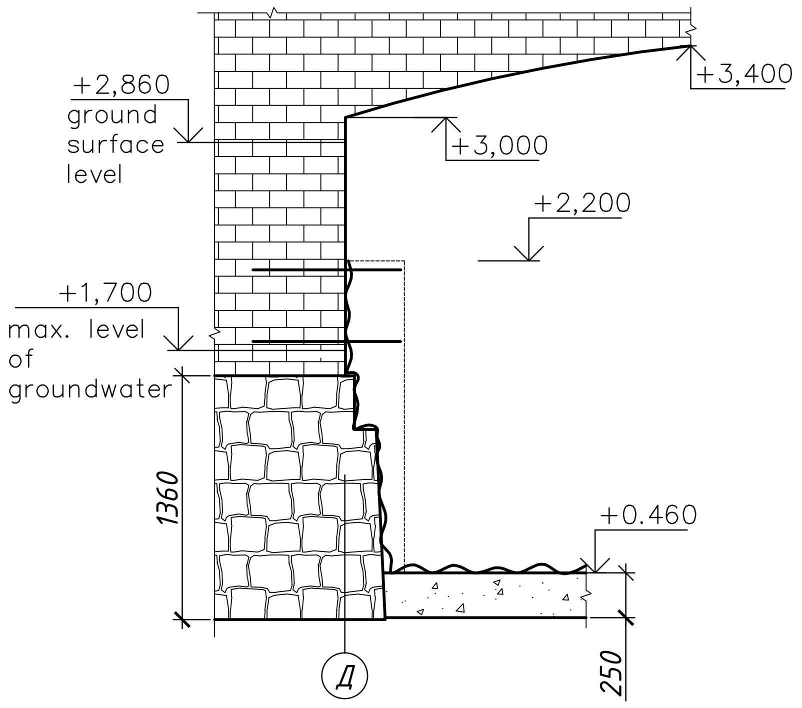
Pos.	Designation	Title	Amn.	Mass kg	Annotation
		Details			
1	GOST 5781-82*	ø18 A400 L=550..730	972	1.46	1087
2	GOST 5781-82*	ø18 A400 L= m	2300	1.998	4595.4
3	GOST 5781-82*	ø12 A400 L= m	1550	0.888	1376.4
4	GOST 5781-82*	ø8 A240 L= m	3485	0.395	1376.6
		Materials			
		Concrete B30 W4 F100	207	m^3	

1. Existing reinforced concrete slabs connected to each other in the doors openings. For it necessary to destroy concrete, clean armature, dismantle the rubble foundation structure, weld armature to the armature reinforced concrete wall and slab and concrete.
2. In the rooms with ground floor basement, to concrete the slab on the one level, without kinks.
3. After slab concreting carried out the drilling of the holes for installation of vertical and horizontal anchors.
4. Make a hydro dynamic cleaning of the concrete, brick, rubble surfaces.
5. Make a repairing of the brick and rubble masonry seams.
6. Make a plaining of vertical surfaces of the brick and rubble masonry for following application of hydro isolation .
7. Application of the bitumen–polymer hydro isolation to the all vertical and horizontal surfaces.
8. Make a concreting of vertical walls, and horizontal pressure–exerting slab.
9. Hydro isolation see the sheet №4.

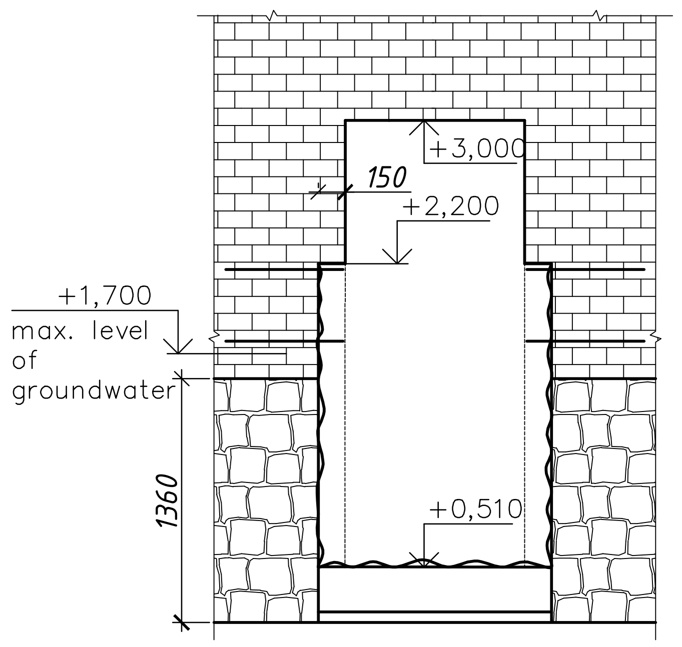
Chang.	Partic.	Sheet	N doc.	Sign.	Date	Saint–Petersburg, Galernaya Street, house 19; Anglyiskaya Embankment, house 20; Zamyatin Lane, house 2		
Developed		Fedorov			2015	Basement floor hydro isolation	Stage	Sheet	Sheets
							P	3	11
						Reinforcement of the slab and pressure–exerting walls	ООО ГЕОИЗОЛ		

Size A2

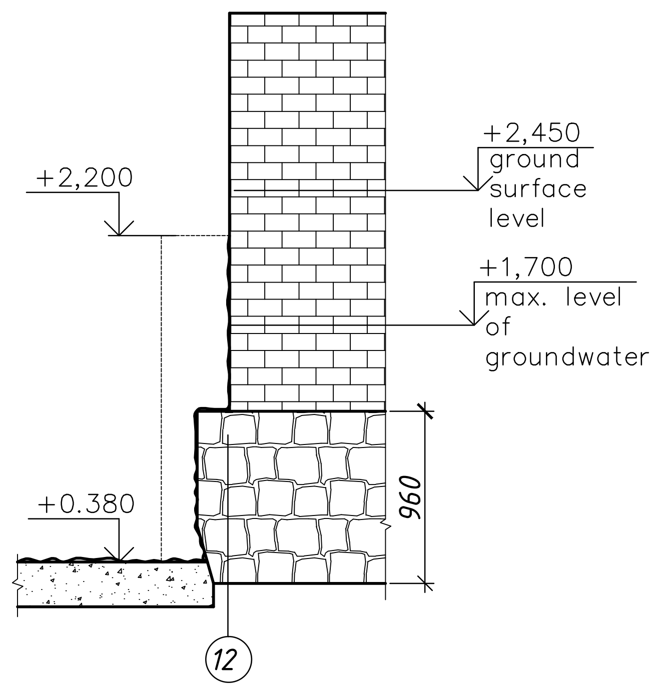
1-1(1 stage)



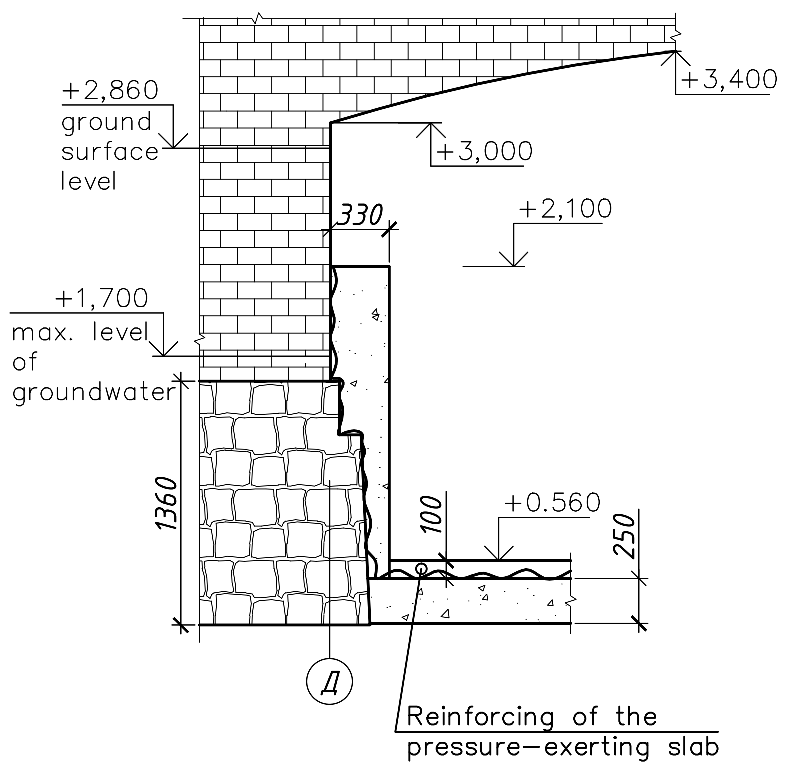
3-3(1 stage)



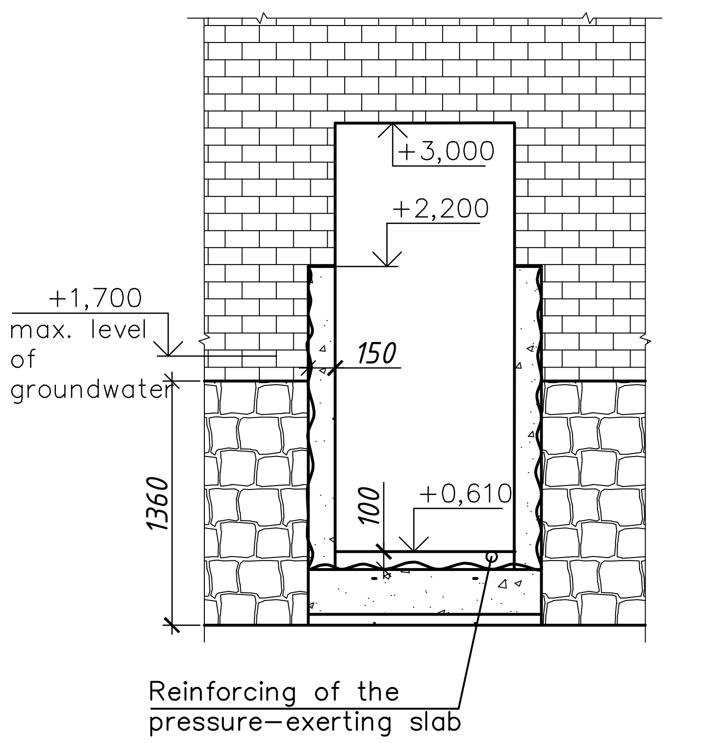
4-4(1 stage)



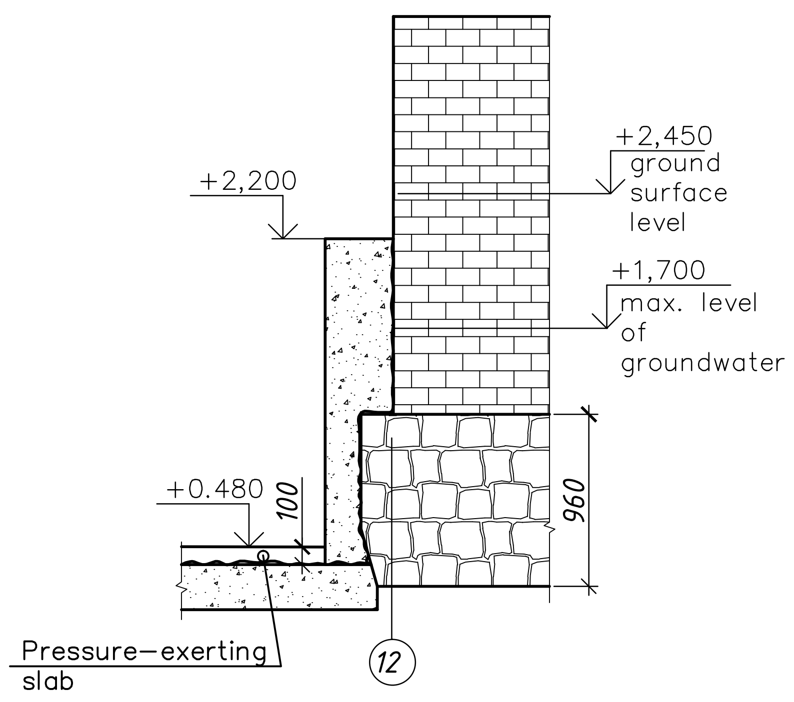
1-1(2nd stage)



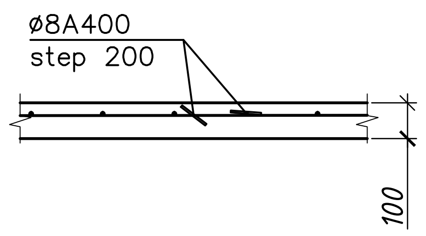
3-3(2nd stage)



4-4(2 stage)



Reinforcing of the pressure-exerting slab



List of works amount

N	Type of the works	Meas. units	Amount
1	Hydro pressure cleaning of the vertical surfaces	m^2	352
2	Hydro pressure cleaning of the horizontal surfaces	m^2	280
3	Repairing of the brick masonry seams	m	5990
4	Plaining of the vertical surfaces	m^2	352
5	Application of the bitumen mastic Bitflex on the paint net	m^2	632
6	Installation of the reinforced concrete slab t=100mm	m^2	260
7	Application of the sanitizied plastering	m^2	44
	Materials		
	Repairing composition Renovir Bricks	kg	5990
	Cement plaining composition Alit Gr-1	kg	10560
	Bitumen mastic Bitflex	kg	1580
	Paint net	m^2	632
	Sanitizing plastering Renovir DryPlast	kg	1584
	Concrete B15	m^3	26
	Armature ø8 A400	m	2860

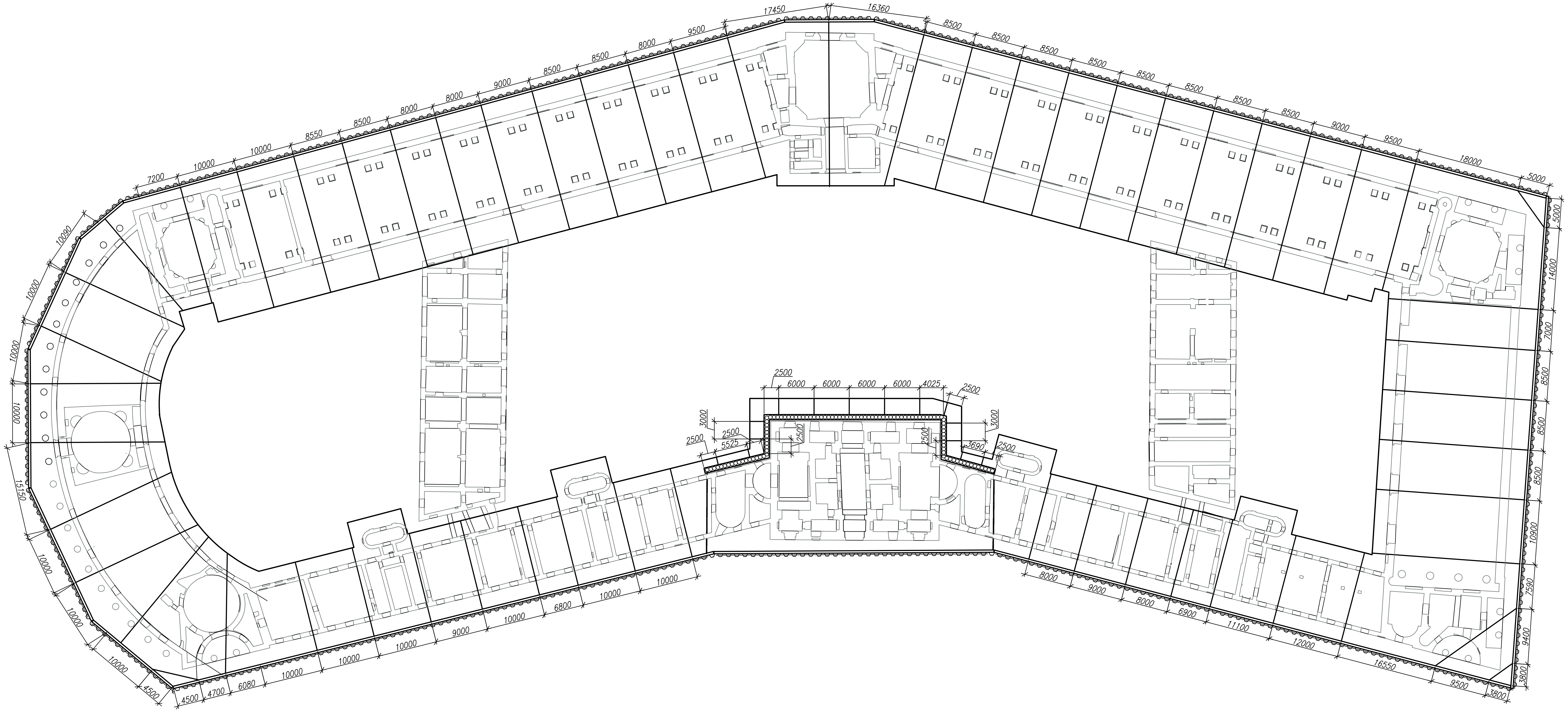
Order of the works:

1. Make hydro jetting cleaning of the brick or rubble walls masonry, as well as the existing reinforced concrete slab.
2. Fill seams in the brick or rubble masonry by repairing composition Renovir Bricks.
3. Plane the brick or rubble masonry surface by cement composition Alit Gr-1 width 20mm.
4. Apply on vertical and horizontal surfaces the bitumen-polymer composition Bitflex with installation of the plastic paint net 4x4mm.
5. Above the waterproofing to make the pressure-exerting slab width 100mm.
6. Apply to the external walls the sanitized plastering Renovir DryPlast to the level of the vault bottom.

Chang.	Partic.	Sheet	N doc.	Sign.	Date	Saint-Petersburg, Galernaya Street, house 19; Anglyiskaya Embankment, house 20; Zamyatin Lane, house 2			
Developed		Fedorov			2015	Basement floor hydro isolation	Stage	Sheet	Sheets
							P	4	11
						Hydro isolation	ООО ГЕОИЗОЛ		

Size A2

Installation scheme of the enclosing structures

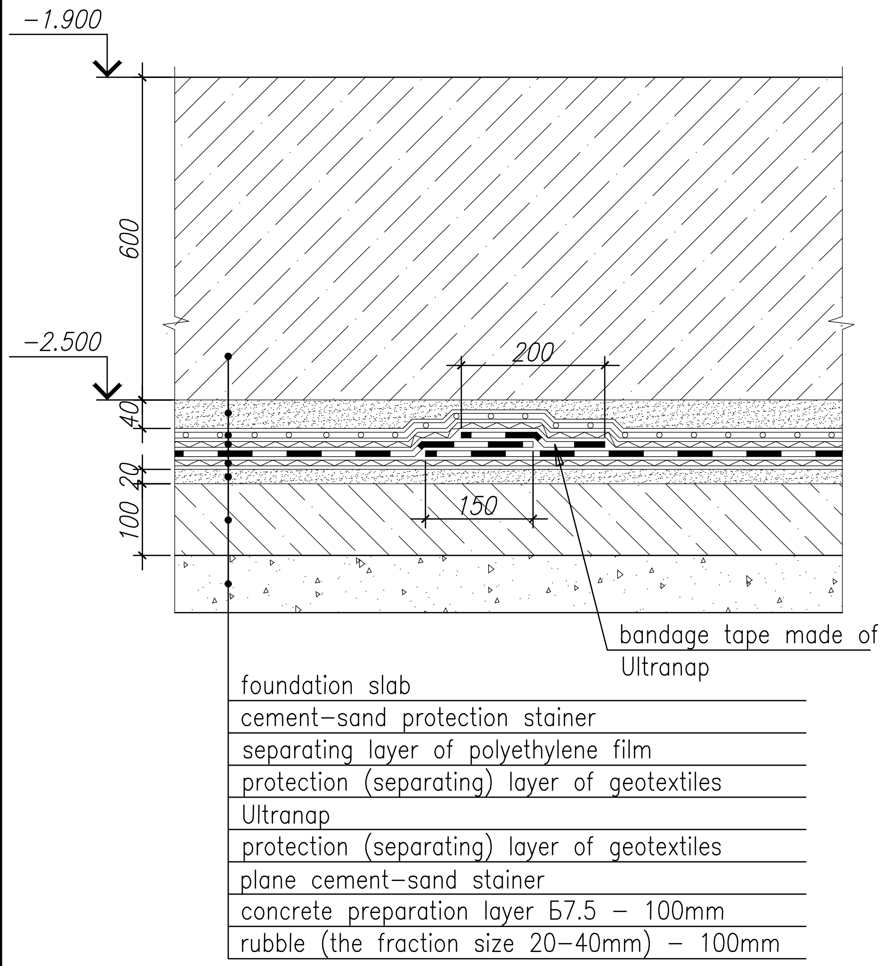


1. Under plate of caisson execute the preparation of rubble, rammed into the ground (80mm), 2 layers of polyethylene film, cement-sand stainer (50 mm).
2. Before the start of the waterproofing works, dismantle all temporary walls, dismantle the floors, to dig out the ground to design level, complete all works, which are provided before the waterproofing works
3. Waterproofing system see sheet 6

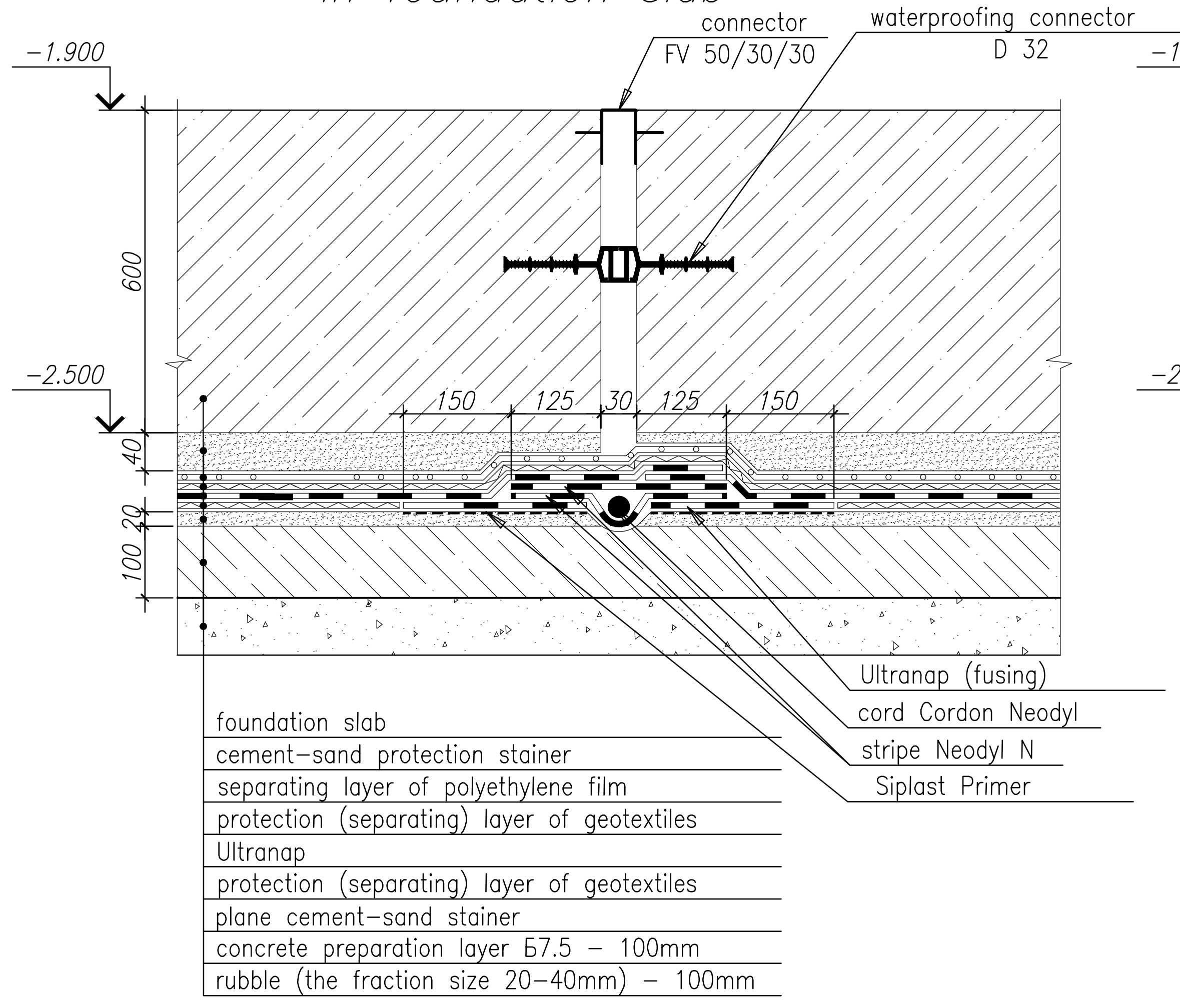
						Adaptation for contemporary usage of the building located at Central District, Konyushennaya Square, house 1, lit. A, in a hotel complex			
Chang.	Partic.	Sheet	N doc.	Sign.	Date				
Developed		Fedorov			2015	Constructive solutions of underground part Installation of enclosing structures	Stage	Sheet	Sheets
							P	5	11
						Installation scheme of the enclosing structures	ООО"АРМ"Рест" ООО"ГЕОИЗОЛ"		

Size A2

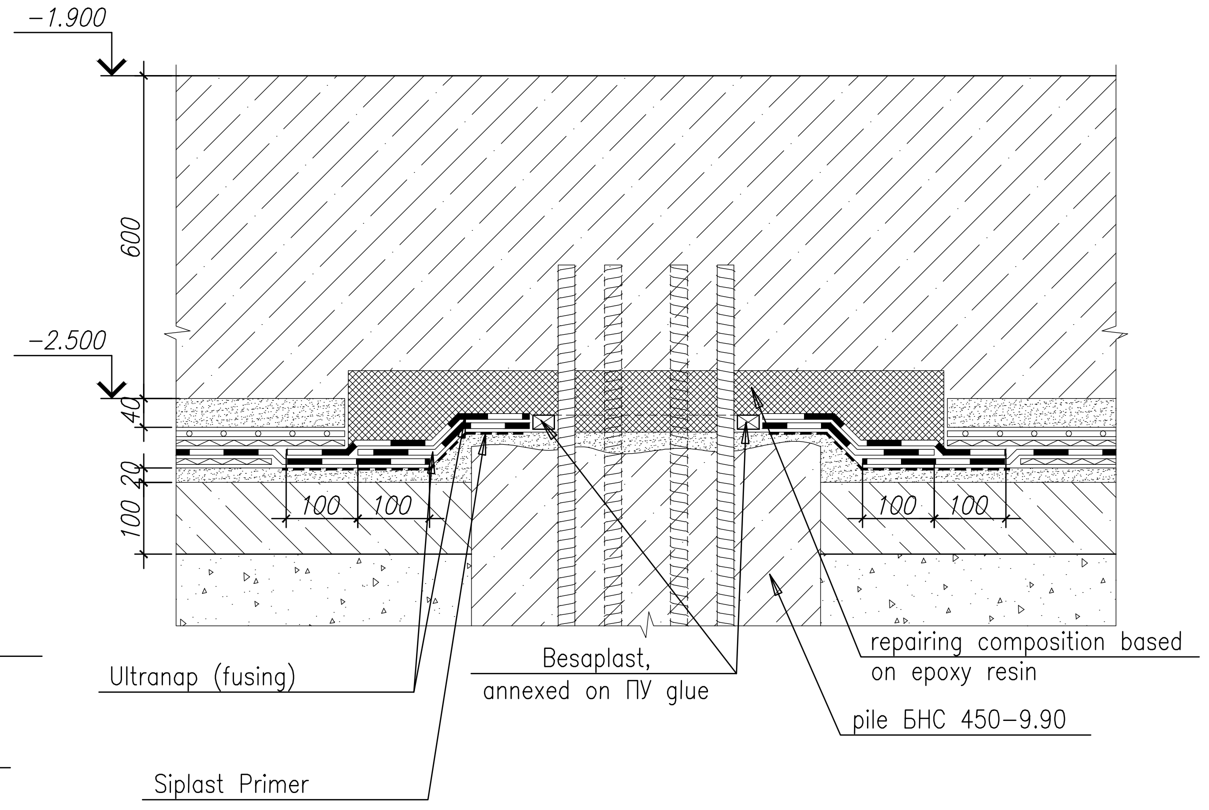
Foundation slab waterproofing



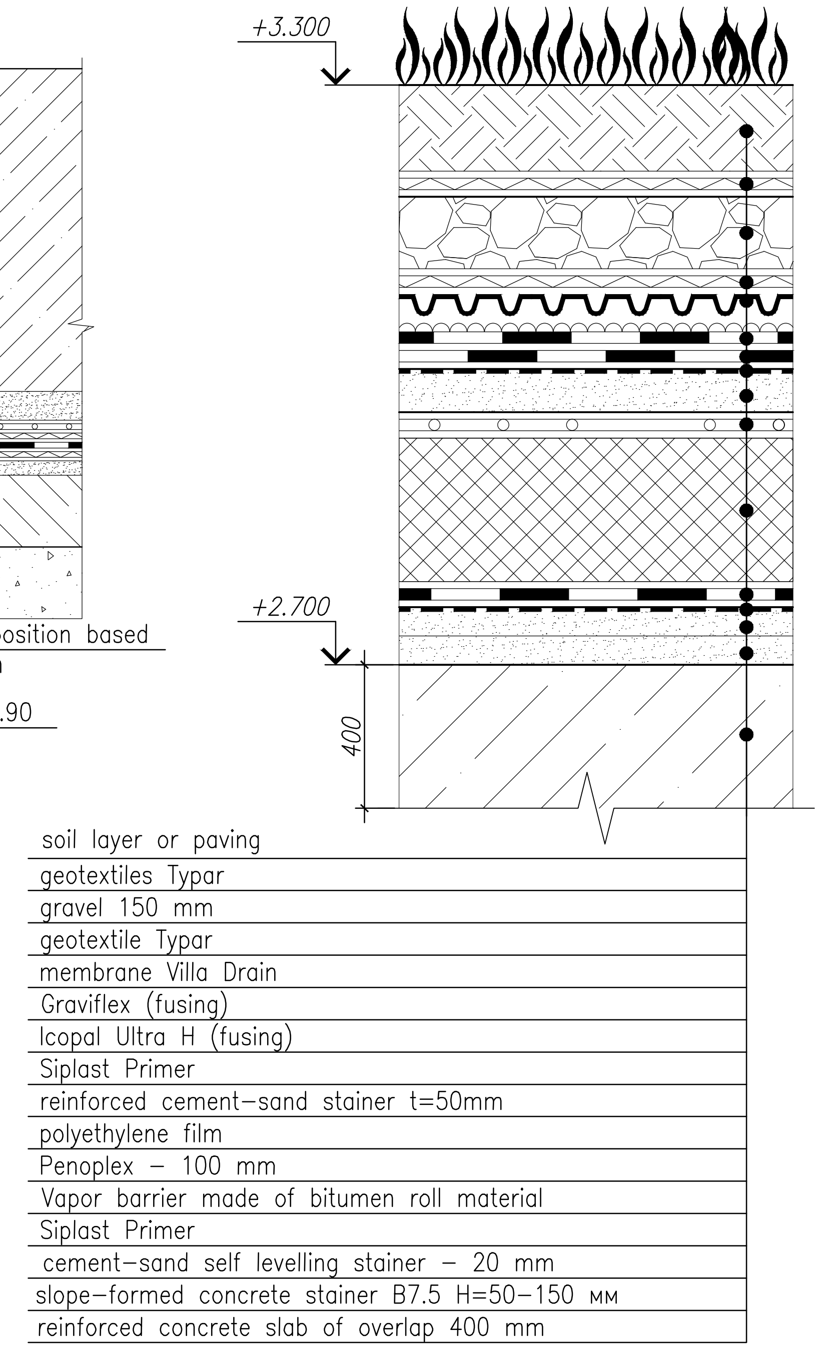
Junction of deformation seam in foundation slab



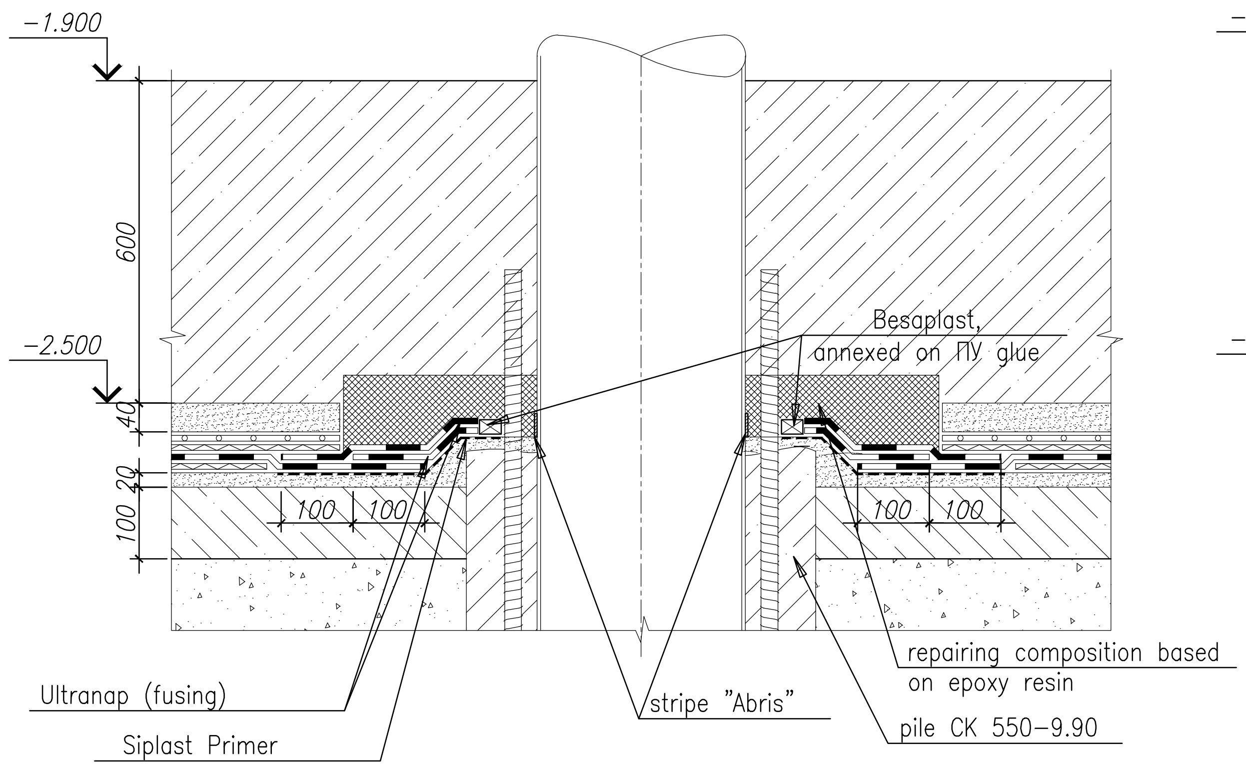
Junction of pile БНС 450-9.90 embedding to the foundation slab



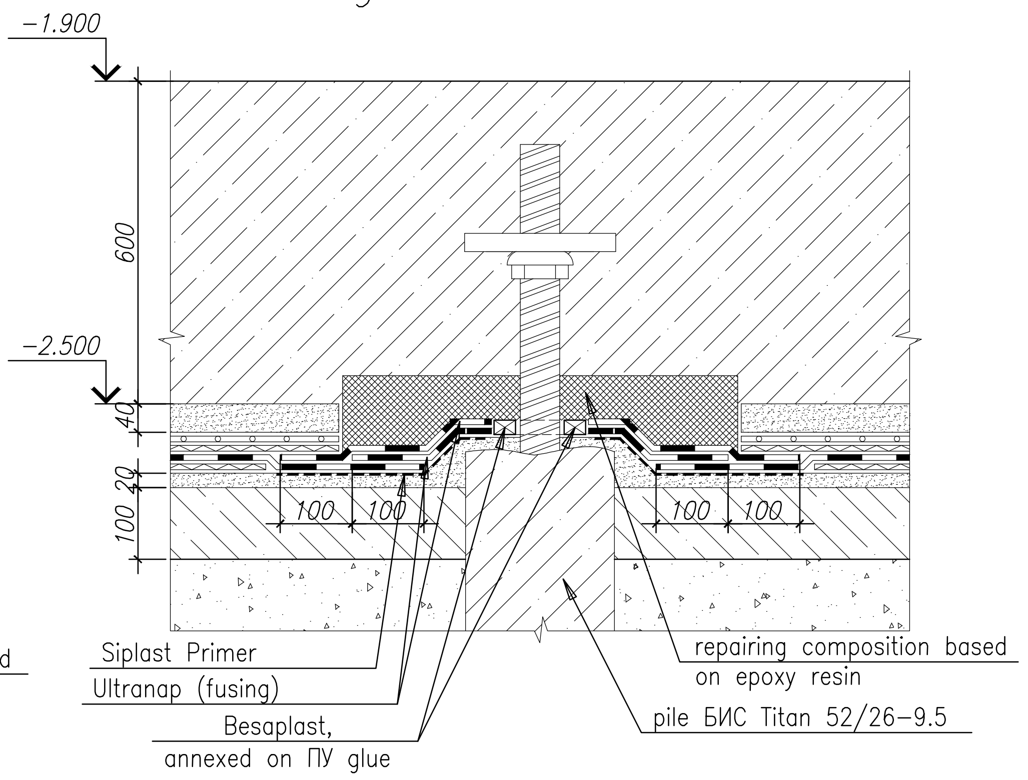
Waterproofing of exploited roof



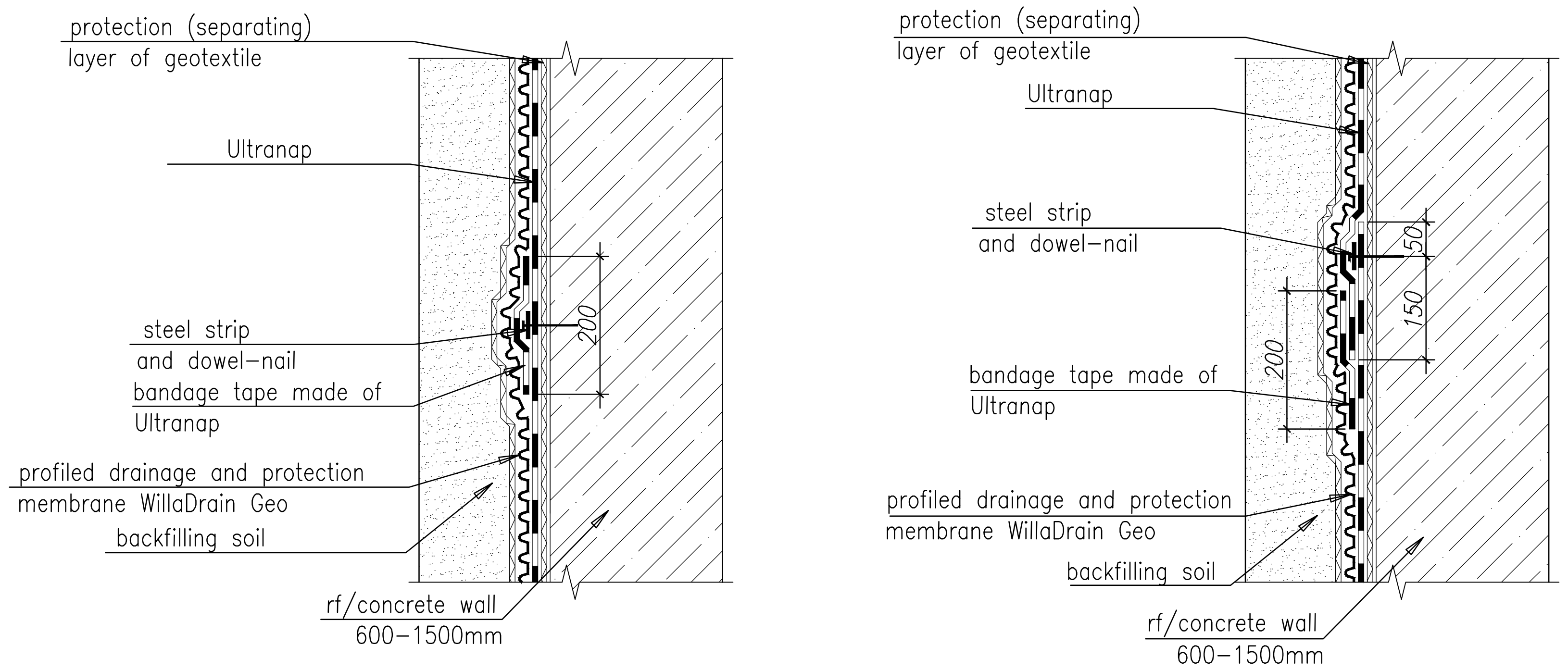
Junction of pile CK 550-9.90 embedding to the foundation slab



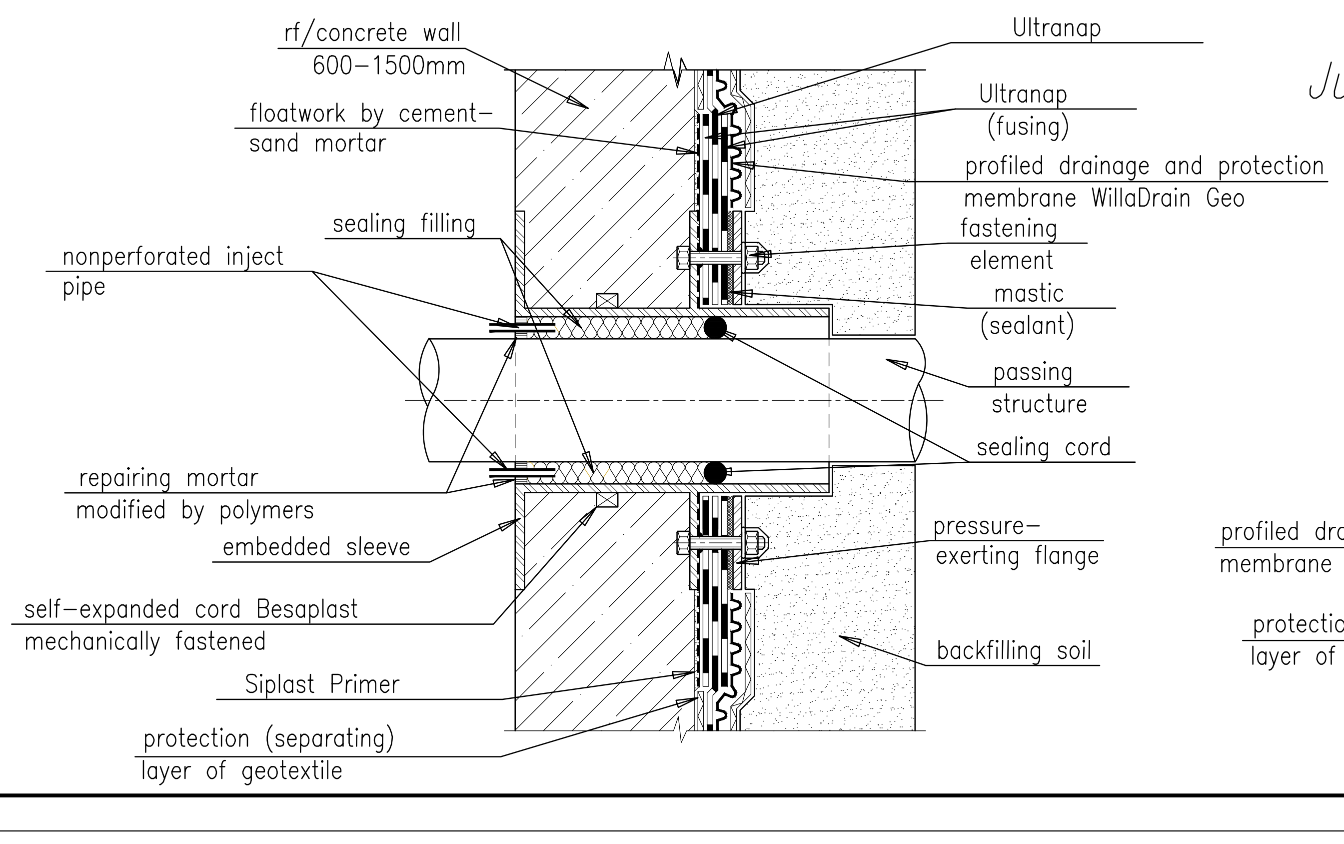
Junction of pile БИС Titan 52/26-9.5 embedding to the foundation slab



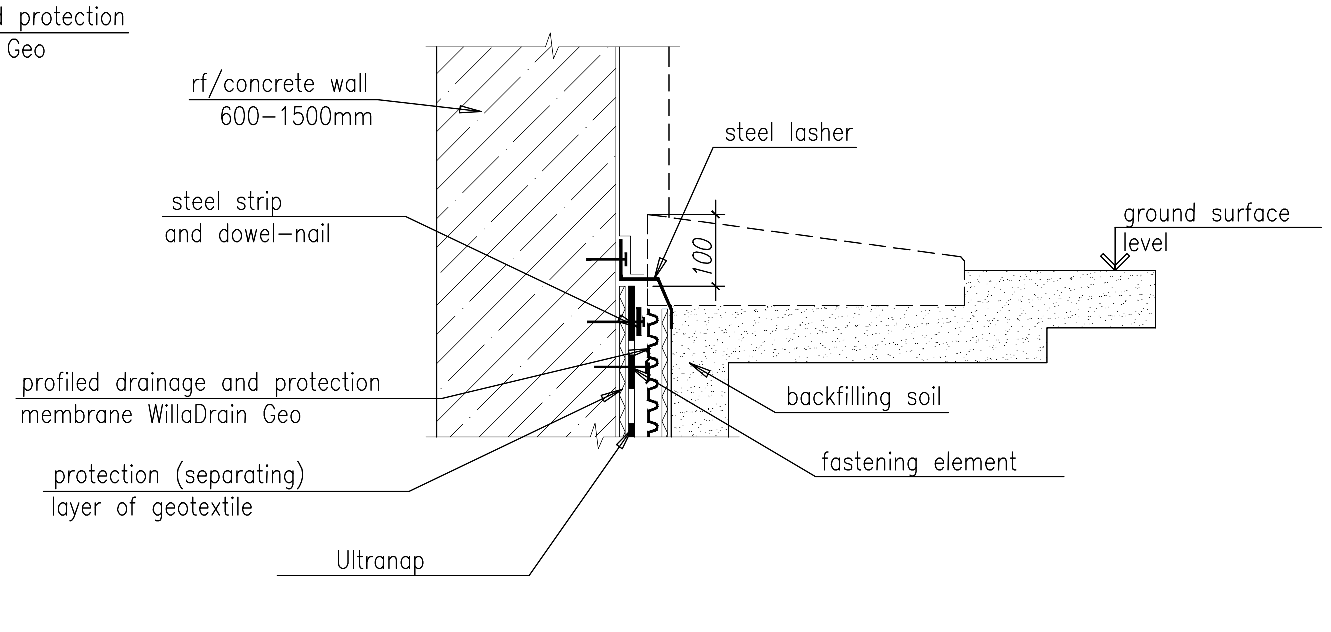
Wall waterproofing



Junction of network entrance hermetic sealing



Junction of waterproofing in the socle area

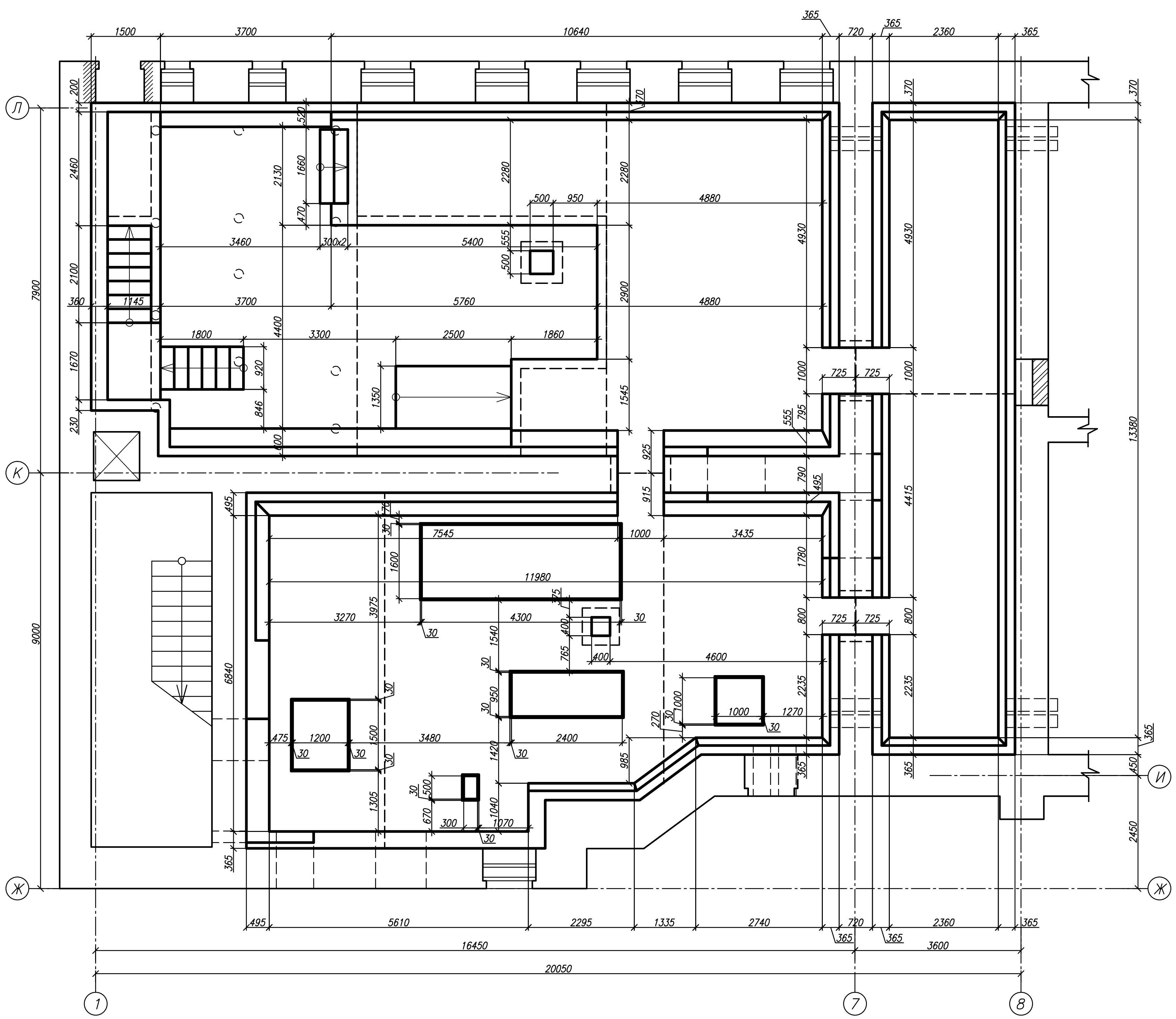


1. Project is made in absolute level marks
2. Guidelines for waterproofing technology must be accordance to the technological regulations and "Guidelines on the application of waterproofing materials production of company ICOPAL"

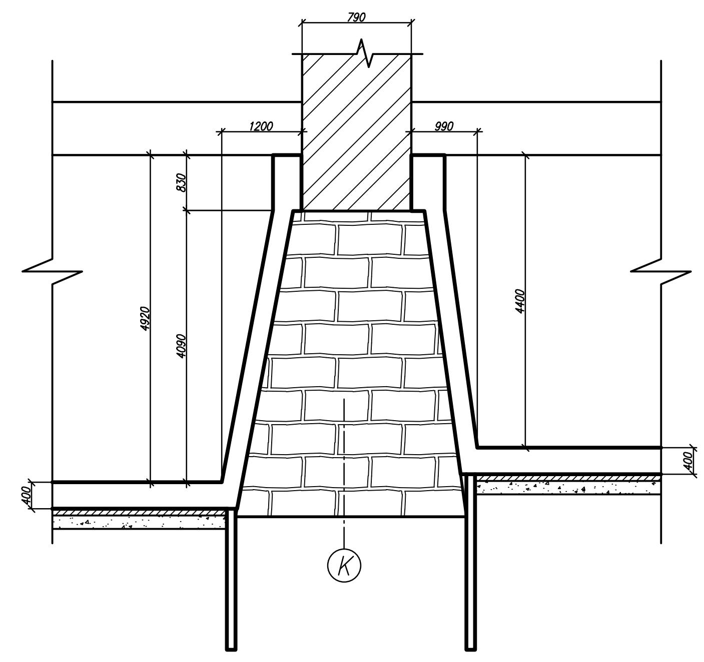
Chang.	Partic.	Sheet	N doc.	Sign.	Date	Adaptation for contemporary usage of the building located at Central District, Konyushennaya Square, house 1, lit. A, in a hotel complex			
Developed		Fedorov			2015	Constructive solutions of underground part Waterproofing of underground building part	Stage	Sheet	Sheets
							P	6	11
						Waterproofing junctions	ООО"АРМ "Рест" ООО"ГЕОИЗОЛ"		

Size A2

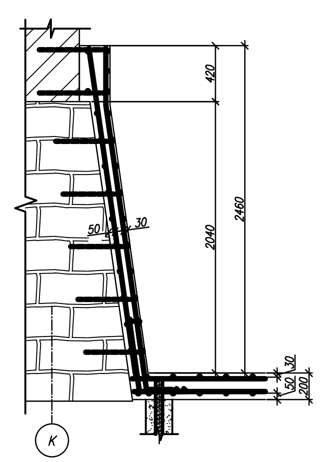
Scheme of slab location in levels −1.420, −2.700, −3.560, −3.820



Scheme of reinforced concrete caisson



Scheme of reinforcement



1. Under plate of caisson execute the preparation of rubble, rammed into the ground (80mm), 2 layers of polyethylene film, cement–sand stainer (50 mm).
2. Before the start of the waterproofing works, dismantle all temporary walls, dismantle the floors, to dig out the ground to design level, complete all works, which are provided before the waterproofing works
3. Waterproofing system see sheet 8

Chang.	Partic.	Sheet	N doc.	Sign.	Date
Developed		Fedorov			2015

Saint–Petersburg, Mayakovskyi Street, house 36–38

Apartment redesigning for offices of CISC "Pilon". Basement floor structures

Stage	Sheet	Sheets
P	7	11

Scheme of slab location in levels −1.420, −2.700, −3.560, −3.820. Scheme of reinforced concrete caisson. Scheme of reinforcement

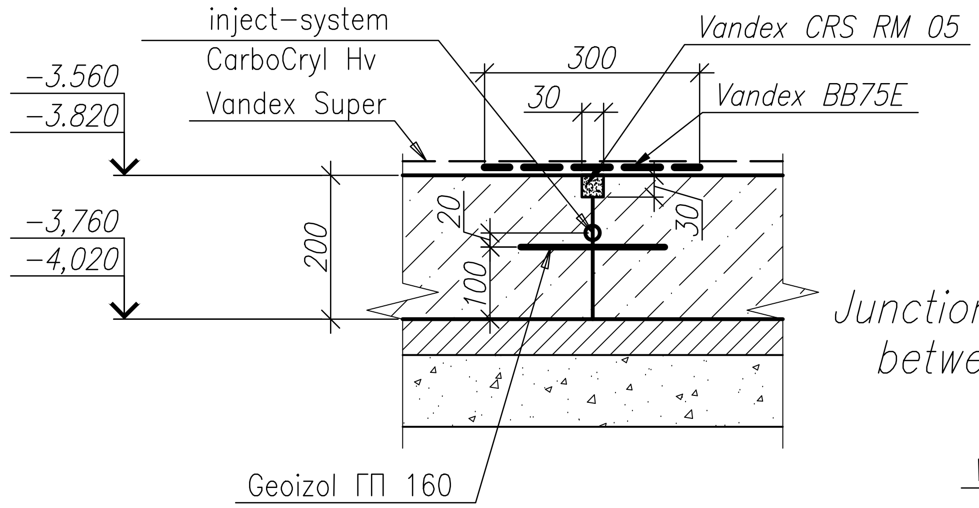
OOO ГЕОИЗОЛ

Size A3

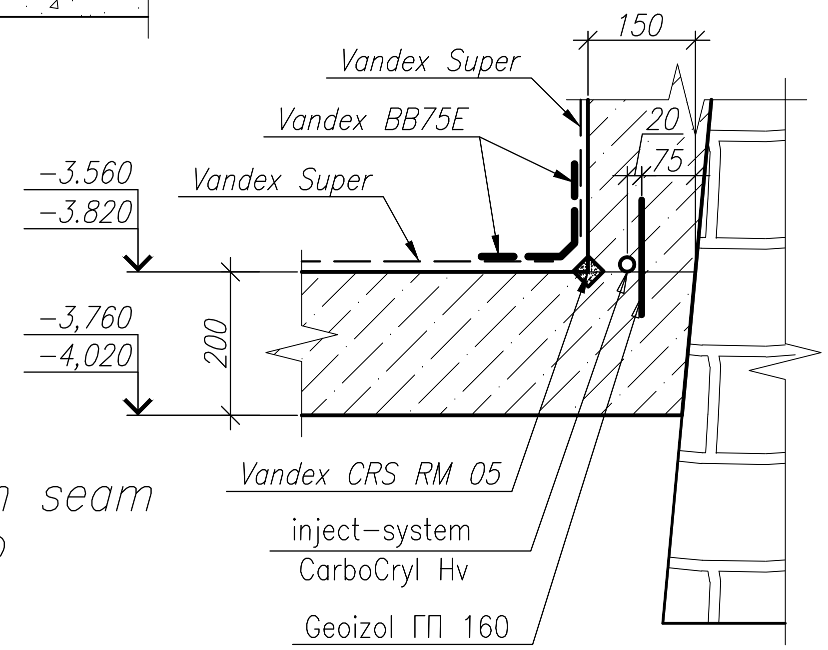
List of works amount

N	Type of the works	Meas. units	Amount
	Lowering of the basement floor level		
1	Development of filed-up ground/sand	m^3	200/130
	Waterproofing of the working seams of foundation slab		
2	Installation of Geoizol ГП 160	m	170
3	Installation of the inject-system	m	170
4	Flowrate of the inject-system	m	170
5	Seam punching 30x30mm	m	170
6	Embedment of the seams by repairing composition	m	170
7	Installation of elastic hydro isolation on the seam	m^2	51
	Waterproofing of the deformation seams of foundation slab		
8	Installation of the inject-system	m	61.4
9	Flowrate of the inject-system	m	61.4
10	Installation of the connector D32	m	30.7
11	Installation of the connector FV 50/30/30	m	30.7
12	Seam filling by extruded polystyrene	m^3	0.2
	Гидроизоляция фундаментной плиты и стенок		
13	Application of waterproofing coating	m^2	485
	Protection of the embedded details		
14	Application of an emanel "Эмакоут 7320 C" in 3 layers (50мсм)	m^2	35.6
	Materials:		
	Geoizol ГП 160	m	30.7
	Connector D 32	m	30.7
	Connector FV 50/30/30	m	30.7
	CarboCryl Hv	kg	350
	Vandex CRS RM 05	kg	425
	Vandex BB75E	kg	255
	Extruded polystyrene	m^3	0.2
	Vandex Super	кg	730
	Emacout 7320 C	l / kg	15.3 / 17.1

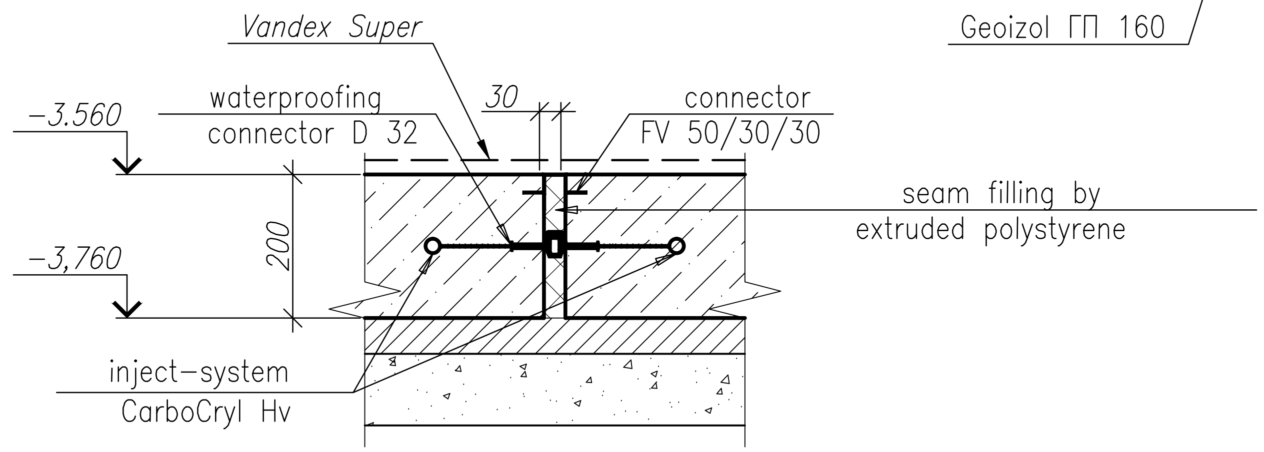
Junction of the working seam in foundation slab



Junction of the working seam between the slab and wall



Junction of deformation seam in foundation slab



Chang.	Partic.	Sheet	N doc.	Sign.	Date
Developed		Fedorov			2015

Saint-Petersburg, Mayakovskyi Street, house 36-38

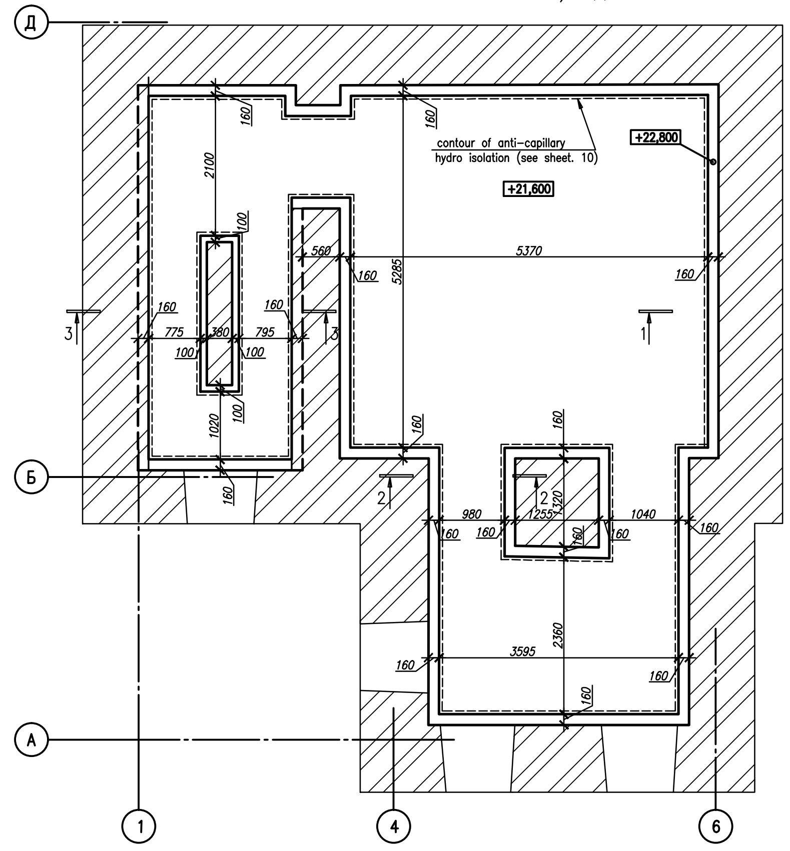
Apartment redesigning for offices of CISC "Pilon". Basement floor structures

Stage	Sheet	Sheets
P	8	11

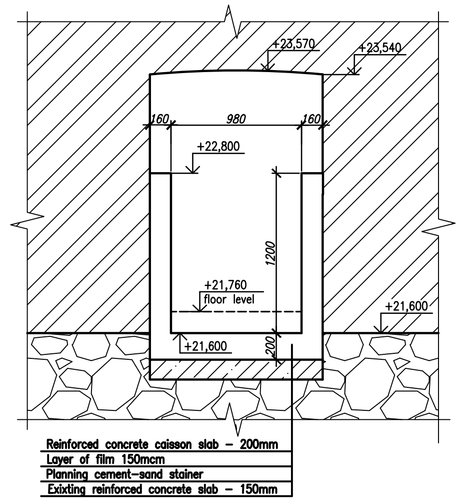
Junctions of structures waterproofing
List of works amount

ООО ГЕОИЗОЛ

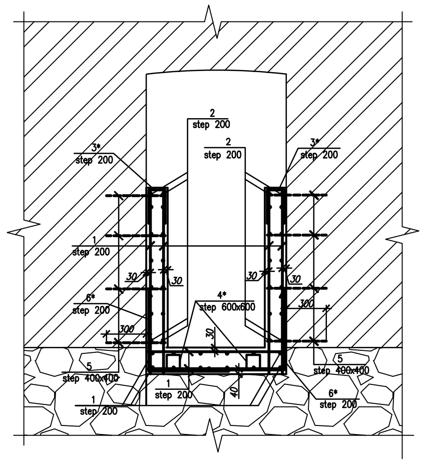
Scheme of caisson slab in the axes 1–6/А–Д.



2–2 (Formwork)



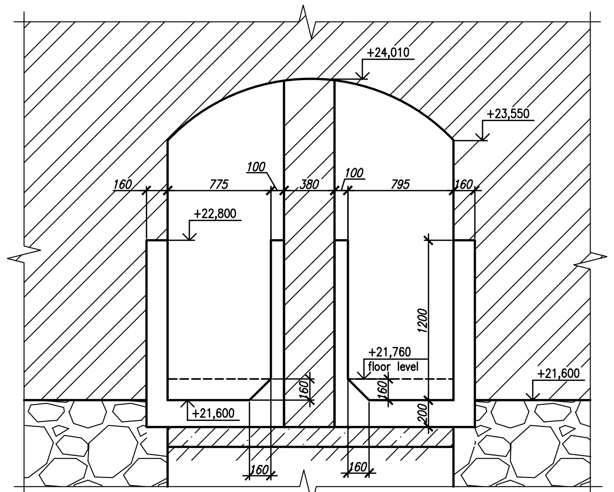
2–2 (Reinforcement)



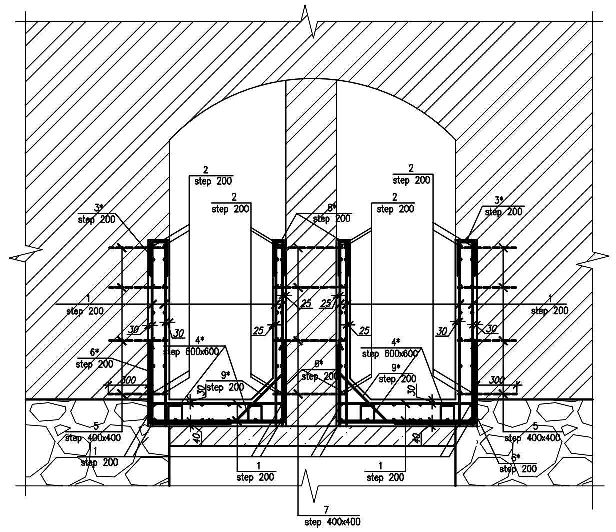
Specification for monolithic caisson reinforcement

Pos.	Designation	Title	Amn.	Mass kg	Annotation
		Monolith caisson slab			
1	GOST 5781–82*	ø12 A400 L, п.м.	603	0.888	535
4*	GOST 5781–82*	ø8 A240 L=510	147	0.20	30
6*	GOST 5781–82*	ø12 A400 L=1200	278	1.07	297
9*	GOST 5781–82*	ø12 A400 L=1000	29	0.888	26
		Materials			
		Concrete B25 W6 F100	12.1		м^3
		Monolith caisson walls			
1	GOST 5781–82*	ø12 A400 L, п.м.	790	0.888	702
2	GOST 5781–82*	ø8 A240 L, п.м.	823	0.395	325
3*	GOST 5781–82*	ø8 A400 L=590	257	0.23	59
5	GOST 5781–82*	ø18 A400 L=450	500	0.90	450
7	GOST 5781–82*	ø18 A400 L=560	20	1.12	22
8*	GOST 5781–82*	ø8 A400 L=550	29	0.22	7
		Mateials			
		Concrete B25 W6 F100	10.4		м^3

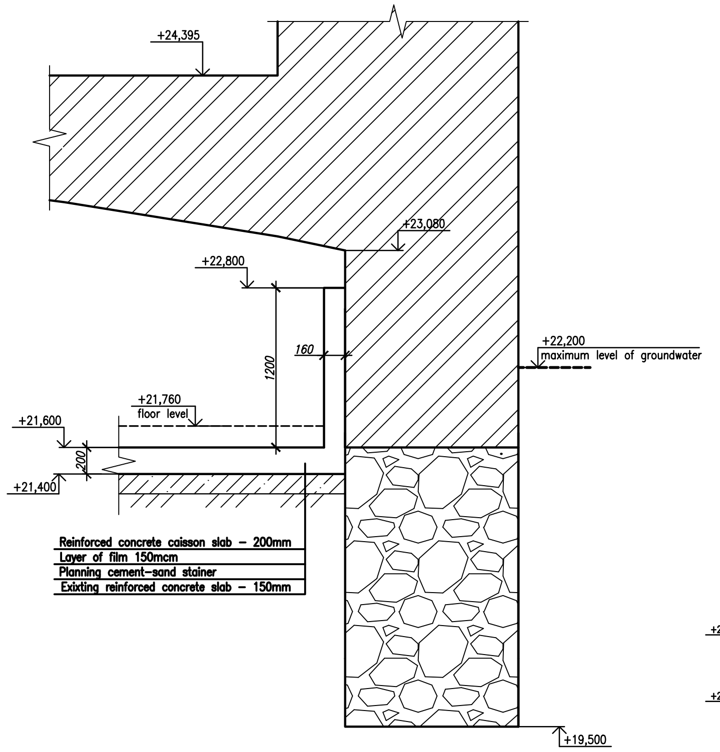
3–3 (Formwork)



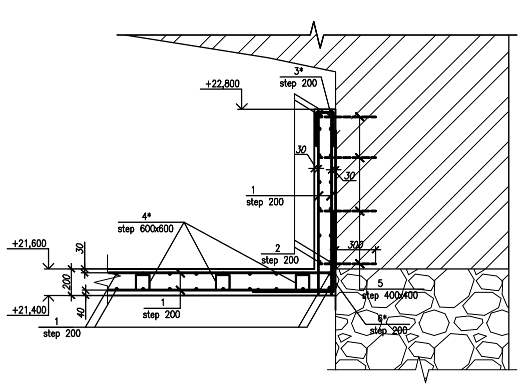
3–3 (Reinforcement)



1–1 (Formwork)



1–1 (Reinforcement)

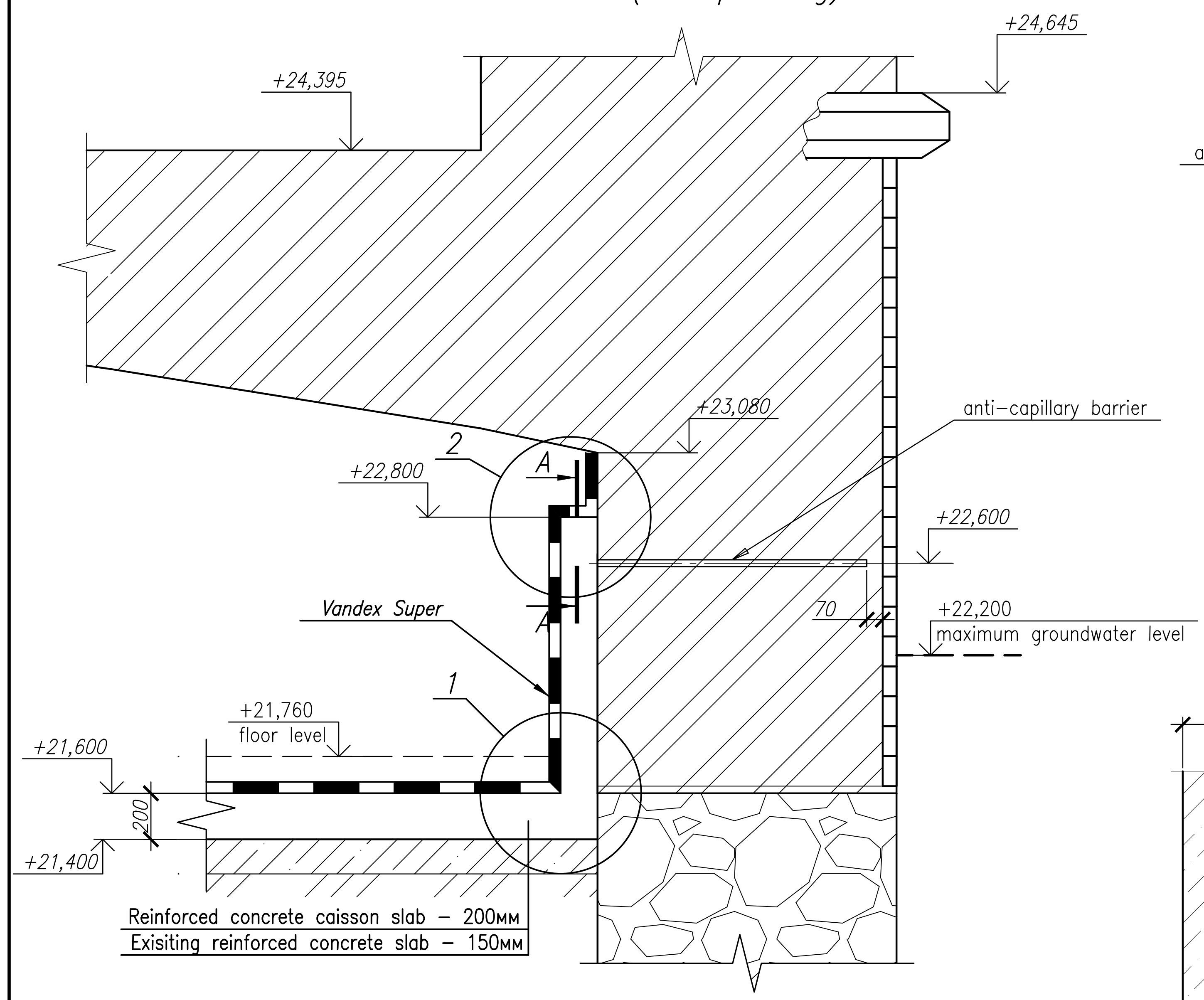


1. Under plate of caisson execute the preparation of rubble, rammed into the ground (80mm), 2 layers of polyethylene film, cement–sand stainer (50 mm).
2. Before the start of the waterproofing works, dismantle all temporary walls, dismantle the floors, to dig out the ground to design level, complete all works, which are provided before the waterproofing works
3. Waterproofing system see sheet 9

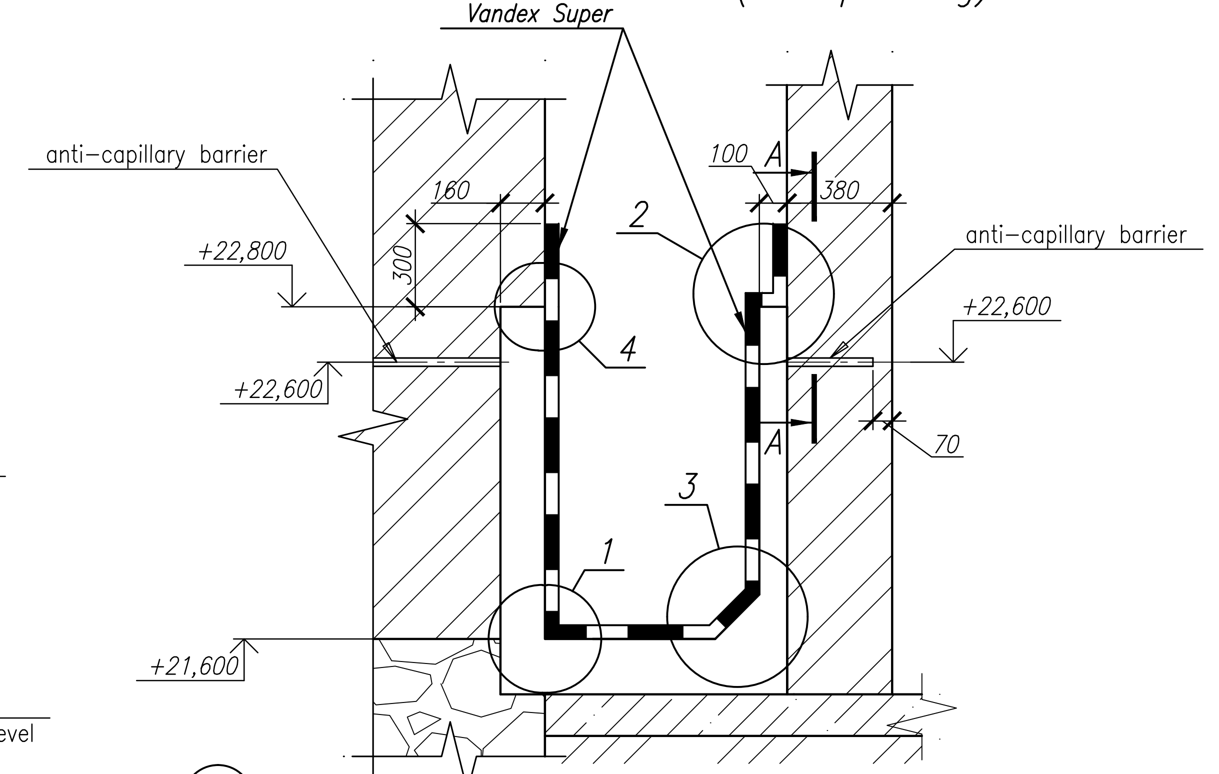
Changes	Partic.	List	№ doc.	Sign.	Date	FGBUK "GMZ"Peterhof" Saint–Petersburg, Kolonistskyi Park, Olgin Island, lit.A.			
Developed		Fedorov			2015	Restoration of the basement floor with installation of hydro isolation and drainage system.	Stage	Sheet	Sheets
							P	9	11
						Scheme of caisson slab in the axes1–6/А–Д. Reinforcement.	ООО ГЕОИЗОЛ		

Size A3

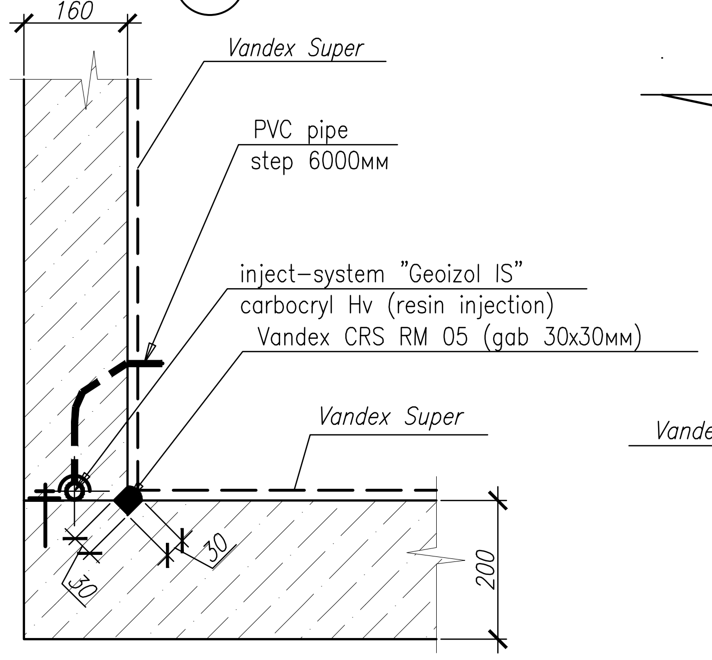
1–1 (Waterproofing)



3–3 (Waterproofing)



1



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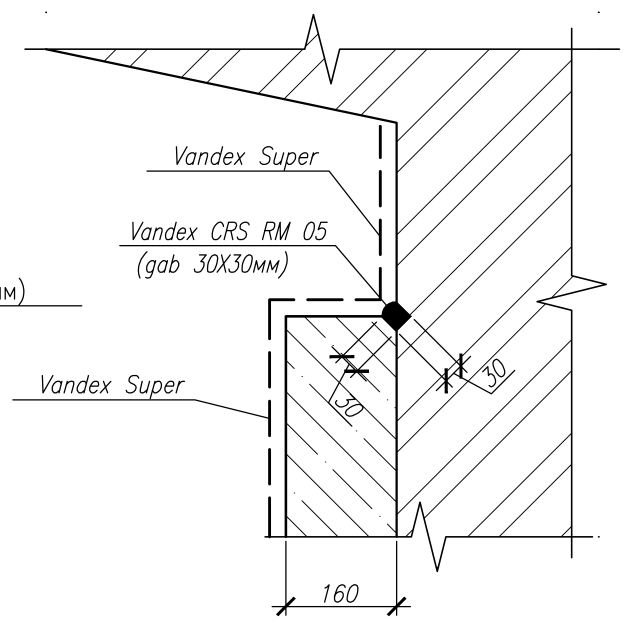
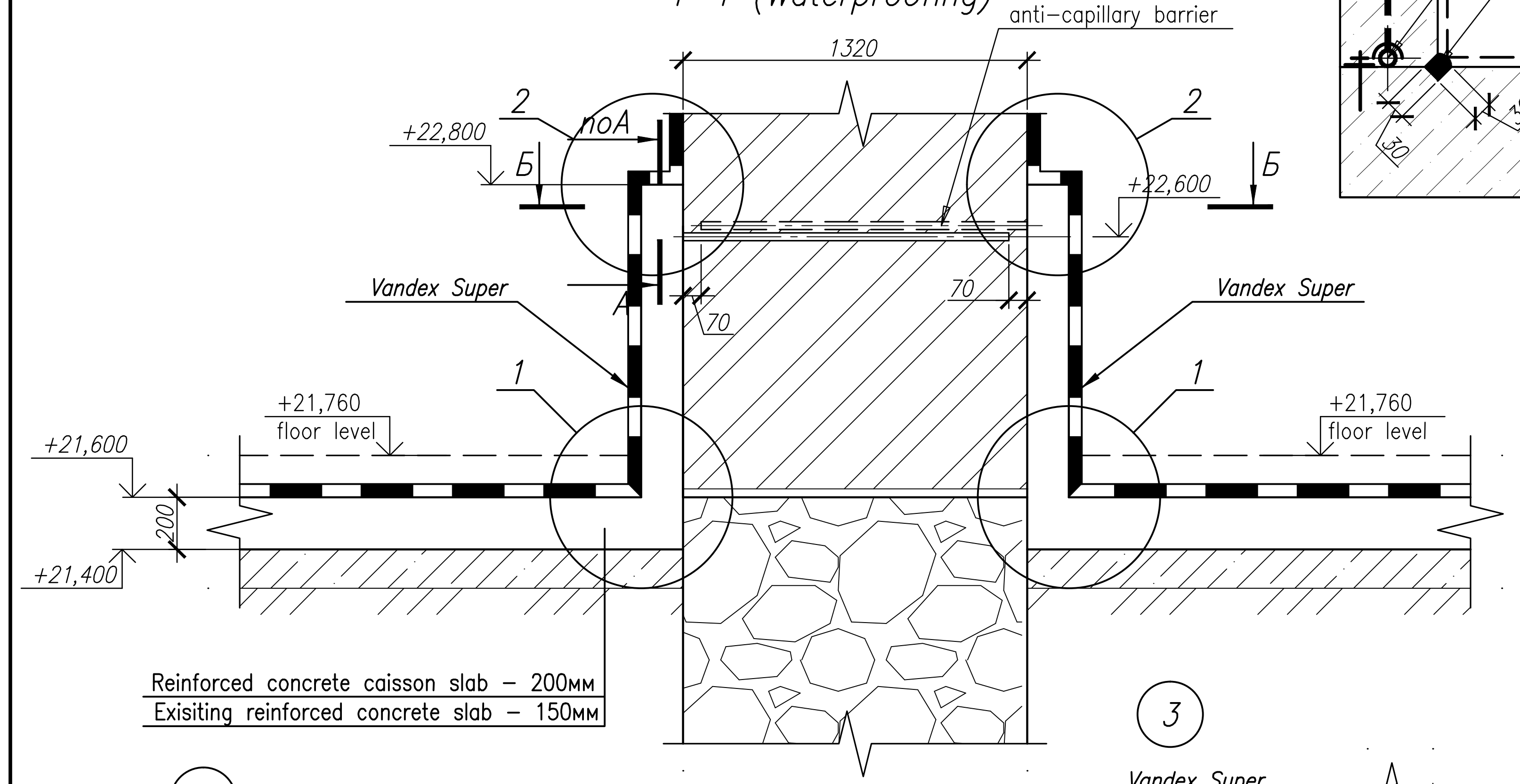
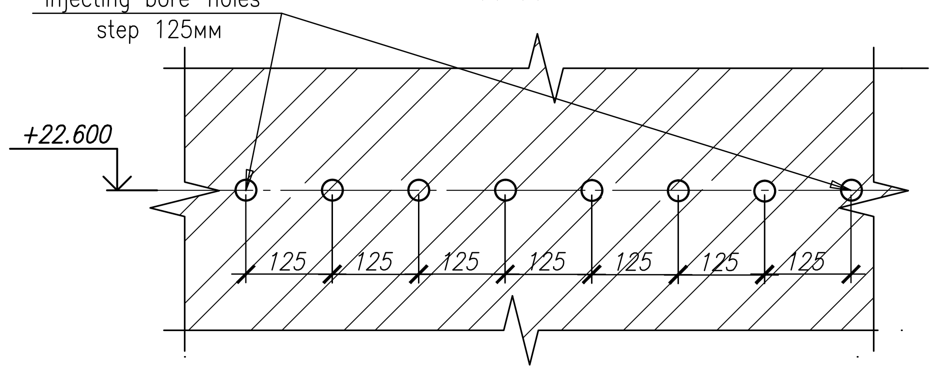


4–4 (Waterproofing)



A–A



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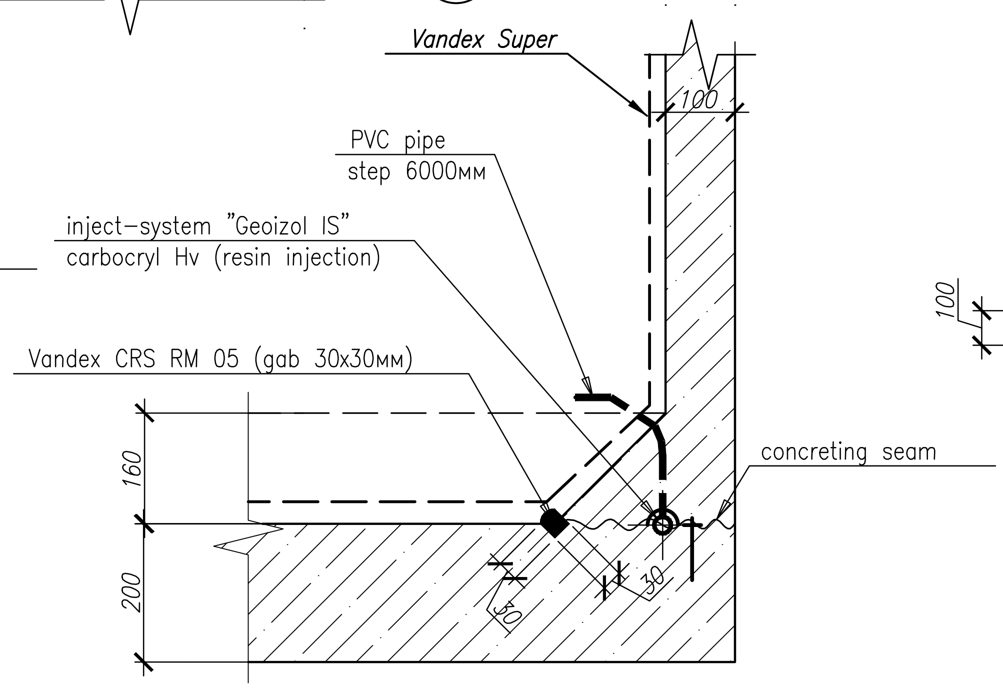

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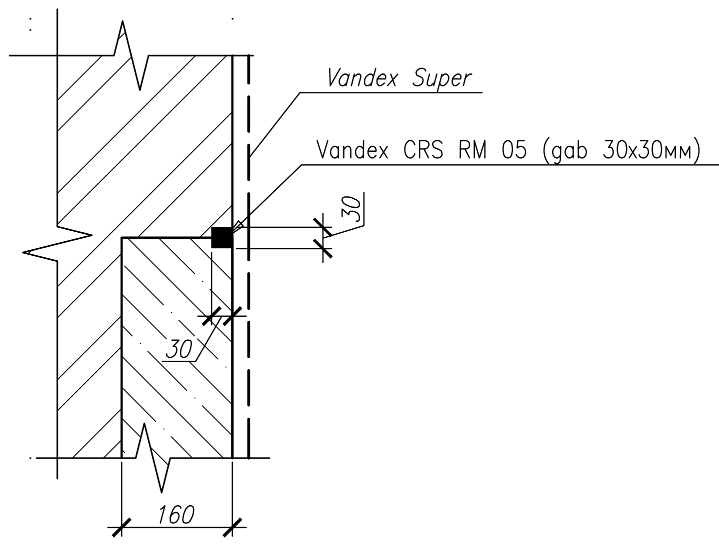
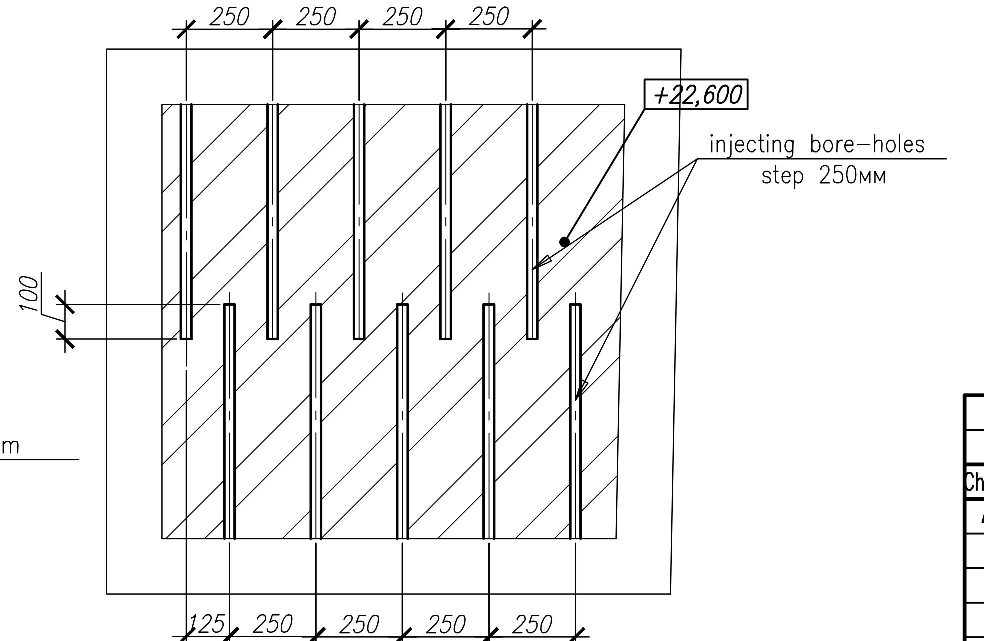


Б–Б



List of works amount

N	Type of the works	Meas. units	Amount
	Installation of caisson slab		
1	Dismantling of limestones slabs t=60мм	m^3	3.2
2	Dismantling of sand preparation layer t=50мм	m^3	2.7
3	Dismantling of cement–sand stainer t=90мм	m^3	4.8
4	Dismantling of reinforced concrete caisson slab t=150мм	m^3	8.0
5	Dismantling of reinforced concrete caisson foundation enlargements t=120мм	m^3	7.4
6	Dismantling of plastering layer thickness 110мм	m^3	3.7
7	Holes drilling ø25 length 0.30м	pcs.	520
8	Anchors installation ø18 A400 on mortar Alit CMA–1	pcs.	520
9	Tussing of brick masonry 160x1200(h)	m	9.8
	Anti–capillary waterproofing		
10	Marking and drilling of injec bore–holes ø25 мм	m	285
11	Injection by lime–cement, truss mortar	m	285
12	Re–drilling of the bore–holes	m	285
13	Injection by hydrophobizator Renovir Microseal	m	285
14	Filling of the bore–holes	m^3	0.15
	Installation of waterproofing		
15	Installation of inject–system	m	57
16	Flowrate of inject–system by acrylate resin	m	57
17	Seam punching into the gabs with minimal width 30x30мм	m	112
18	Seam filling by dimensionally stable repairing composition	m	112
19	Application of covering cement hydro isolation	m^2	96
	Materials		
	Dry mixture Alit CMA–1	kg	125
	Inject–system "Geoizol IS"	m	63
	Acrylate resin "CarboCryl Hv"	kg	86
	Repairing composition "Vandex CRS RM 05"	kg	280
	Covering hydro isolation"Vandex Super"	kg	144
	Cement	kg	2850
	Lime	kg	570
	Renovir Microseal	kg	855
	Water	m^3	23.8

1. Project is made in absolute level marks
2. Length of the inject–system bore–holes specifies on the place and depends on the wall thickness
3. Presence of the reinforced concrete caisson with waterproofing without the installation of the floor structures during a long time is prohibited.

Changes	Partic.	List	N doc.	Sign.	Date
Developed		Fedorov			2015

FGBUK "GMZ"Peterhof" Saint–Petersburg, Kolonistskyi Park, Olgin Island, lit.A.

Restoration of the basement floor with installation of hydro isolation and drainage system.

Stage	Sheet	Sheets
P	10	11

Scheme of caisson slab in the axes 1–6/A–Д. Waterproofing.

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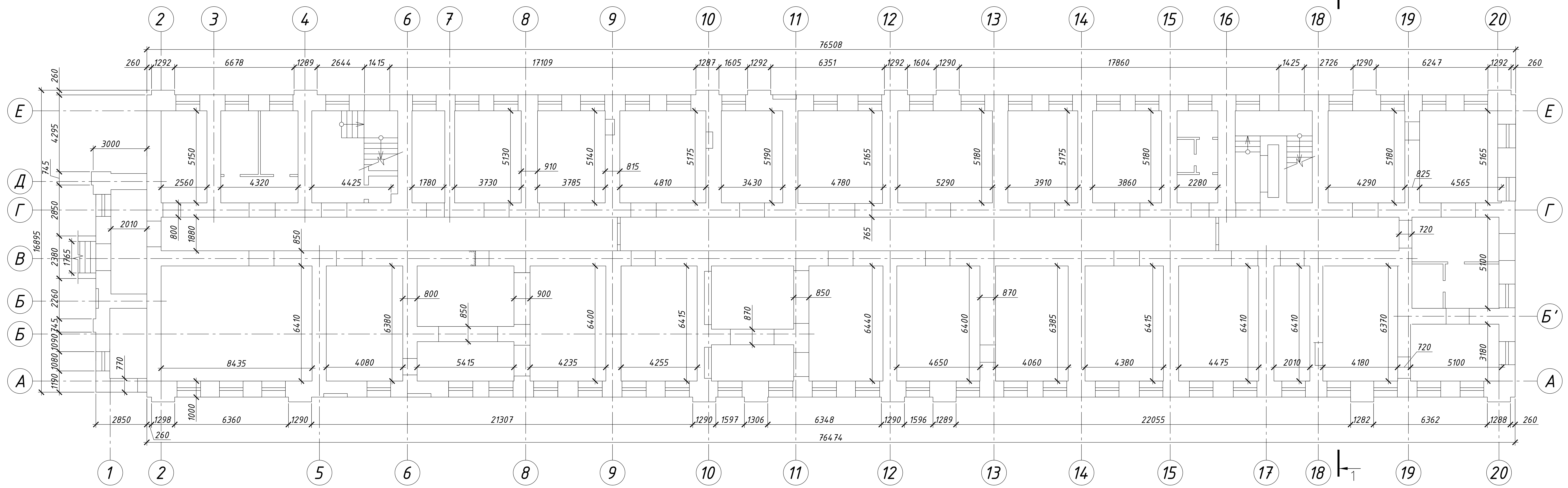
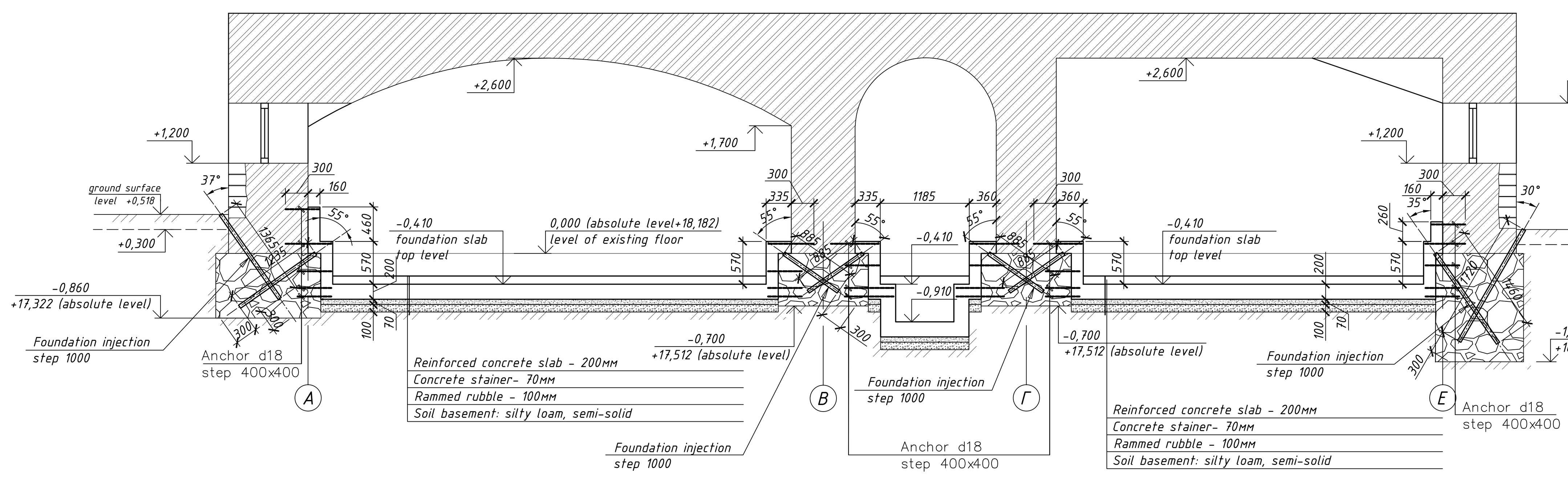
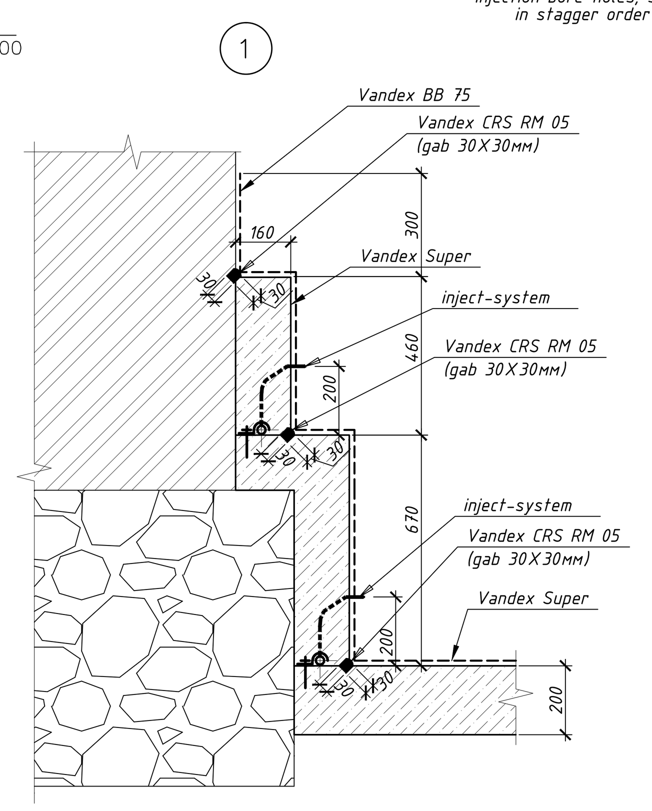
Size A2

Scheme of the socle floor

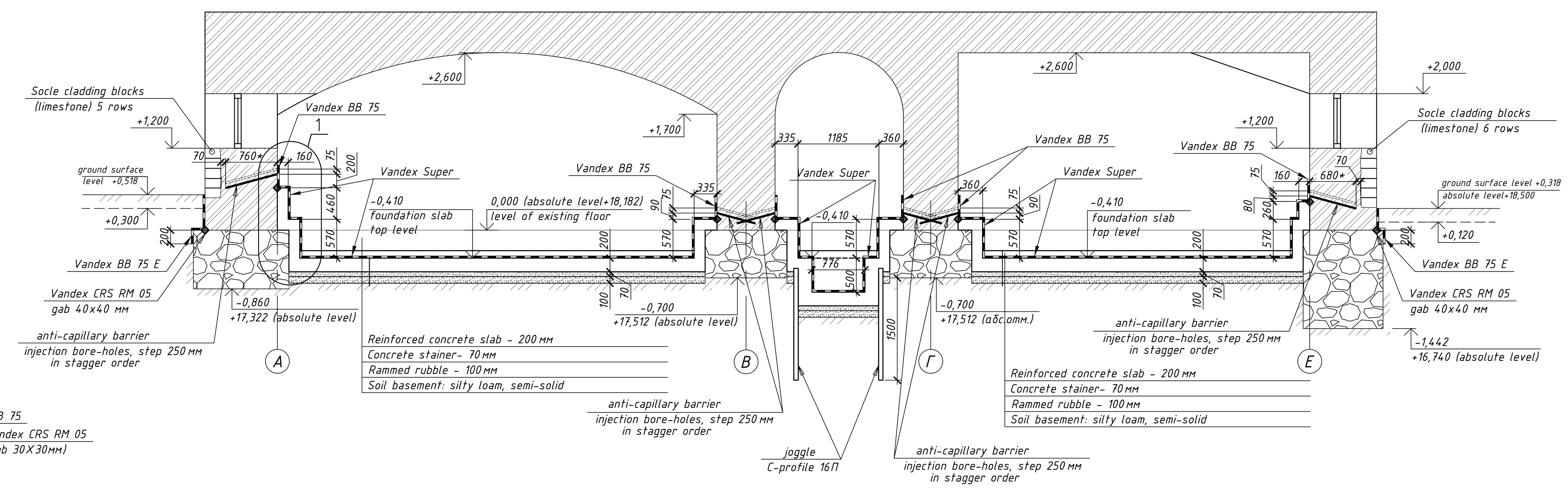


Section 1-1
Constructive solutions





Section 1-1
Waterproofing



1. Under plate of caisson execute the preparation of rubble, rammed into the ground (80mm), 2 layers of polyethylene film, cement–sand stainer (50 mm).
2. Before the start of the waterproofing works, dismantle all temporary walls, dismantle the floors, to dig out the ground to design level, complete all works, which are provided before the waterproofing works

Chang.	Partic.	Sheet	N doc.	Sign.	Date	FGBUK "GMZ" Peterhof"			
Developed		Fedorov			2015	Restoration of the socle floor of the Verchnesadskyi house, located at: Peterhof, Pravlenskaya Street, house 11	Stage	Sheet	Sheets
							P	11	11
						Scheme of the socle floor. Section 1–1. Waterproofing.	ООО ГЕОИЗОЛ		

size A1