Saimaa University of Applied Sciences
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GEOLOGY OF SAINT-PETERSBURG, NOVGOROD, PSKOV REGIONS AND ITS INFLUENCE ON FOUNDATION

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ABSTRACT
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The purpose of this thesis report was to describe the geology situation of Saint-Petersburg, Novgorod and Pskov regions from constructional view, then, with examples of particular building sites from these regions, to compare the archival characteristics with investigation building sites characteristics and to describe a foundation method, which is suitable for described geological conditions.

To reach these goals necessary geology literature was read and analyzed. Also information about building sites and foundation methods was received and elaborated.

After the data had been analyzed, the main necessary ideas and information were written out. Before each part was composed in the final version, it had been checked and discussed with tutors.

Working through and analyzing all this information more deep knowledge in geology and foundations was received. Also the picture of geological structure of the studied area was cleared.

Keywords: Geological region, modern sediments, design scheme, bored piles.

CONTENTS

1 INTRODUCTION

Knowledge of geology, soils, which form a particular type of locality and their properties is the base for any type of foundation and road design.

That is why, FCG company gave the task: on the example of the chosen geological region to study by what tectonic structures the presented region is complicated, sediments of what periods in different parts of this territory are situated and what soils these sediments are composed of, to provide characteristics of the presented soils and to describe geological structures in the studied area.

Also, using the examples of a specific building sites with geological investigation results, there was a goal to compare described geology of soils in region with geology in a specific building sites from this region, to describe the type of chosen foundation, which is suitable for the geological conditions on a building site from region and method of its set.

To narrow down the scope of this thesis, the periods of sediments and how sediments were formed in each of these periods are briefly described. Also information only about two building sites with their geology investigation data was found and among these building sites only one site had information about its foundation methods and so it was taken.

2 GEOLOGY OF SAINT-PETERSBURG, PSKOV AND NOVGOROD REGIONS

2.1 Definition

The territory of Leningrad, Pskov and Novgorod regions is located within two major geological regions of Russian platform: Baltic Shield and Baltic region. (Geology of the USSR, 1971)

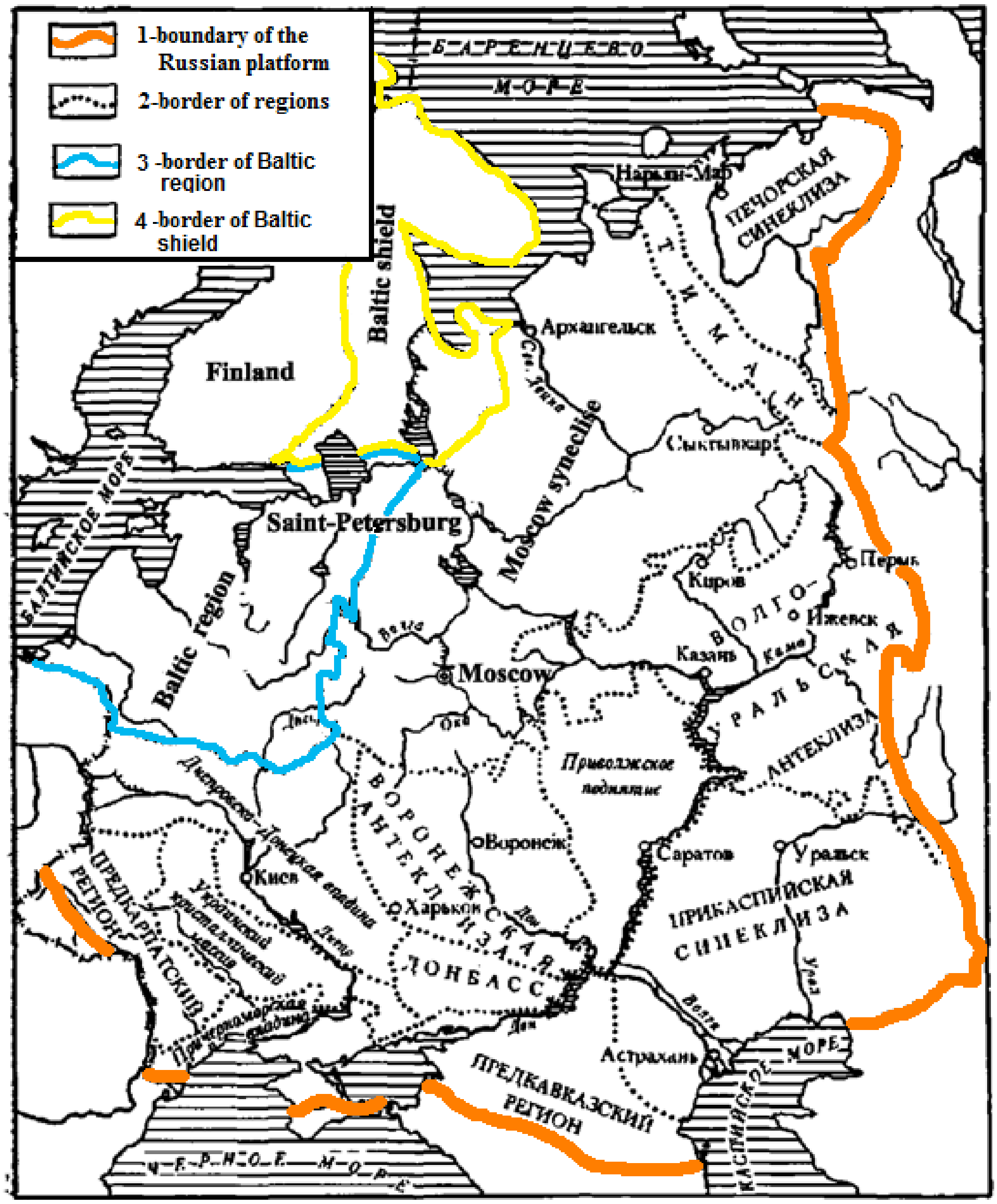

Figure 1 Scheme of engineering-geological zoning of the Russian platform (Geology of the USSR. 1971)

Figure 1 shows studied region with tectonic and geological structures.

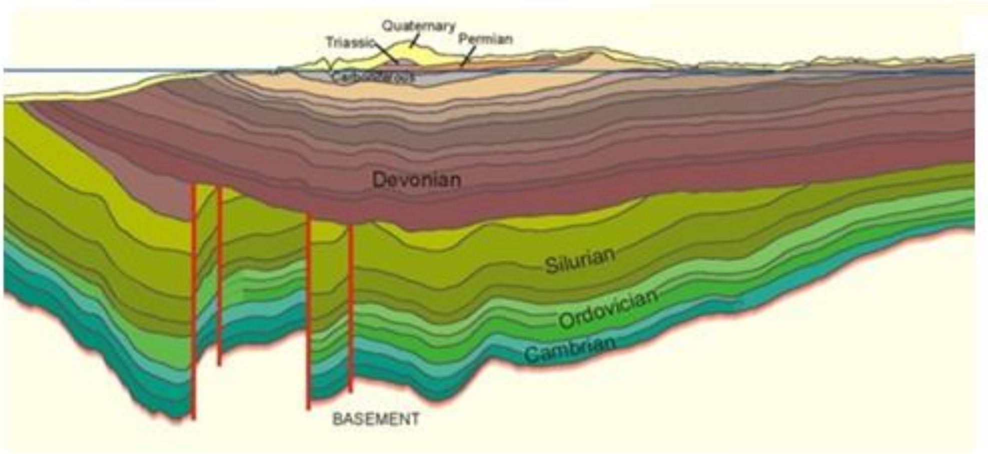

Figure 2 Sediments in different periods (Geology of the USSR, 1971)

Figure 2 shows the major structural elements of the Baltic region and the geological cross-section of sediments, which were formed in each period. This stages are shown in (Appendix 4: Figure 2), (Appendix 4: Figure 3) and (Appendix 4: Figure 4) in tables. For example, Devonian stage has its sediments (in table it is formations of red terrigenous Early Devonian) and this sediments are represented by clays.

2.2 Baltic shield

The Baltic Shield is situated in the north-western part of Russian Platform - Karelia and Kola Peninsula. (Engineering Geology of the USSR, 1978)

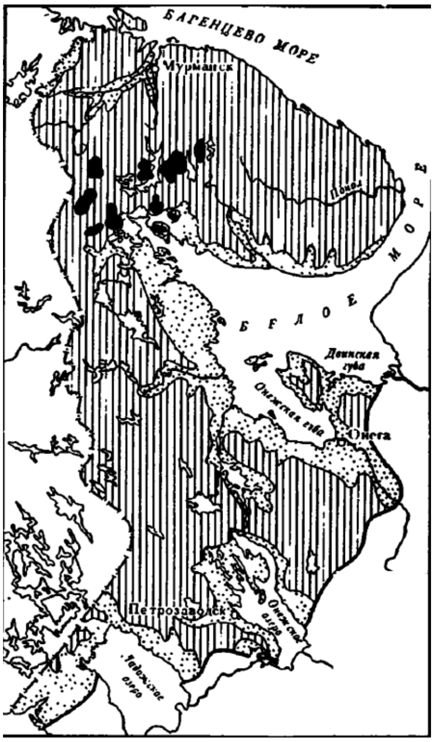

Figure 3 Baltic shield (Geology of the USSR, 1971)

Figure 3 shows the north-western part of Russian Platform - Karelia and Kola Peninsula.

2.2.1 Geology and engineering-geological characteristics of rocks

The Baltic Shield is an ancient before-baikal structure, which is composed of metamorphic rocks of Archean and Early Proterozoic age. (Engineering Geology of the USSR, 1978)

Ancient sediments on the most part of the region lie under a sufficiently high layer (10-170 m) of Quaternary sediments. (Engineering Geology of the USSR, 1978)

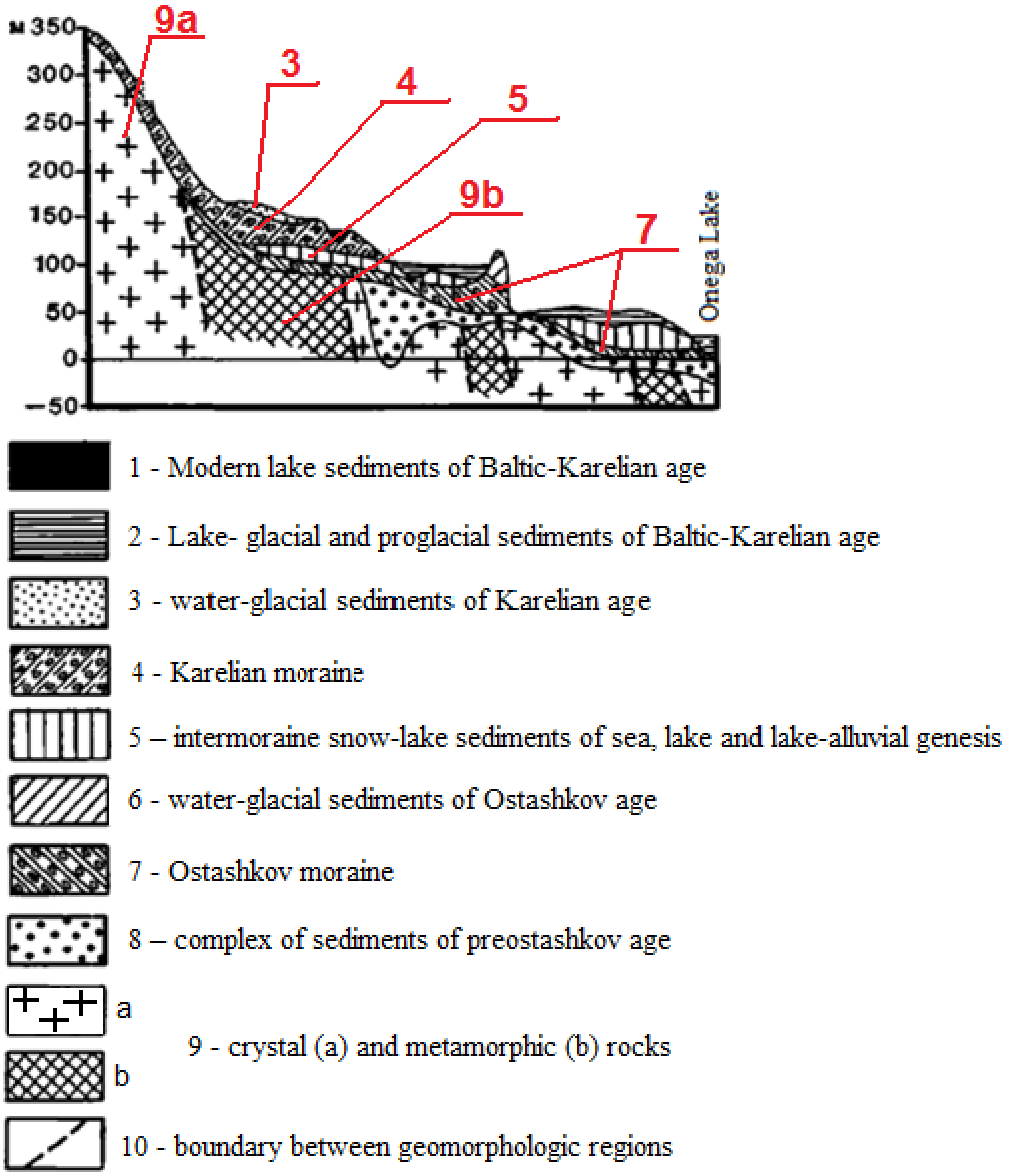

Figure 4 Scheme of the harmonization of rock complexes south-eastern part of the Baltic Shield (Engineering Geology of the USSR, 1978)

Figure 4 shows the cross-section of south-eastern part of the Baltic Shield.

The structure of the Baltic Shield can be divided into three structural stages.

1.The lower structural stage (Archaea – Middle Proterozoic) is composed of metamorphic rocks - gneisses, amphibolites and metamorphic slates, which include the arrays of igneous rocks. They are characterized by high durability and stability. (Engineering Geology of the USSR, 1978)

2.Baikal structural stage (Upper Proterozoic - Lower Cambrian) is composed of conglomerates, sandstones, phyllites and dolomites with total thickness up to 6000 m. Within the region they are developed fragmented (Peninsula Rybachy, island Kildin) and in engineering and geological directions these territories are unknown due to weak development. (Engineering Geology of the USSR, 1978)

3.The structure of Upper Alpine structural stage (middle Pliocene - Holocene) is composed of different in genesis unconsolidated rocks. (Engineering Geology of the USSR, 1978)

Pliocene sediments on the most part of Shield were destroyed by multiple glacial exaration and are survived only in some deep cavities of preglacial relief, where they are in most cases overlapped with layers of younger sediments with thickness of 10 - 50 m. Therefore, the practical importance for the construction on Baltic Shield have only the youngest glacial and postglacial sediments. (Engineering Geology of the USSR, 1978)

2.2.2 Upper Alpine structural stage (Pleistocene-Holocene)

2.2.2.1 Complex of onegoozersk sea, lake and lake-alluvial sediments

It lies under moraine of the last Karelian glacial at a depth of 7 - 10 m and outside it comes up to the surface.

Sea formations are represented by clays, sands, gravel and pebbles; Continental formations are represented by layer of loam, sandy loam and sand. In a number of items were found layers of peat with thickness up to 1.5 m. The maximum known thickness of sediments is 37 m. (Engineering Geology of the USSR, 1978)

From engineering-geological point of view they were studied only in the region of Petrozavodsk, Olonets and East Prionega. Both sea and lake sediments are characterized by considerable heterogeneity. Among sea sandy sediments sands with middle size are dominated; among lake sediments - small and middle-sized. Clays and loams, as a rule, are silty, middle dense, semisolid or tight plastic consistency. (Engineering Geology of the USSR, 1978)

2.2.2.2 Glacial sediments of Karelian and Ostashkov age

They are widespread and on the most part of the area they lie on the surface. Only on the periphery of the shield they overlap with thin temporary formations. The lower horizon of glacial sediments is formed by Ostashkov moraine with variable depth and has thickness of 3 - 20 m. (Engineering Geology of the USSR, 1978)

The upper horizon is Karelian moraine. Lithological composition of the Karelian moraines is also not quite sustained. On the Kola Peninsula in Northern and Central Karelia, where the glacier moved mainly on Precambrian crystalline rocks, it is composed by sand and sandy loam. In areas where the moraine was formed by interglacial sediments its composition is composed by clays and loams Karelian and Onega-Ladozhsk isthmus, Eastern Onega. (Engineering Geology of the USSR, 1978)

The upper layers of moraine cover are represented by ablation moraines, which are distinguished by a rude structure, lower density, more weathering and roundness of clastic material. In addition, moraines often have layers and lenses of boulders and gravel, sand and gravel. Thickness of Karelian moraines increases from north to south from 3 - 5 to 7 - 8 m and in some places (Karelian and Onega-Ladoga isthmuses) increases to 50 - 60 m. (Engineering Geology of the USSR, 1978)

In granulometric composition it is allocated pebble-gravel, sand, sandy loam, loam and clay moraines. For all differences it is characterized the high content of boulders, gravel and pebbles and the heterogeneity of the mechanical structure. (Engineering Geology of the USSR, 1978)

In the petrographic composition of gravel-pebble-boulder material is dominated following local rocks: granite, gneiss, gabbro, diabase, amphiboles and quartzites. In the moraine composition is dominated quartz sand (90%), feldspar (up to 10 - 40%), mica (10 - 15%) in the clay fraction - hydromica. (Engineering Geology of the USSR, 1978)

Significant content of silt particles in moraine sediments can cause freezing heave, which often leads to serious deformation of structures. The information about mechanical properties of moraine sediments of Baltic Shield is very scarce. According to reports the average values of the internal angle of friction in sand at a volume weight of the skeleton of 1.8, 1.9 and 2.0 g/cm^3 are accordingly 30, 33 and 37°. In loam angle of internal friction varies from 25 to 29°; cohesion on 0.015 to 0.082 MPa. (Engineering Geology of the USSR, 1978)

In natural occurrence moraine sediments are characterized by high strength and low compression, in most cases modulus of total deformation varies from 20 to 30 MPa. (Engineering Geology of the USSR, 1978)

2.2.2.3 Fluvioglacial sediments of Karelian age

By Fluvioglacial sediments of Karelian age different forms of relief in internal glacial, out glacial and edge zones are composed. Fluvioglacial sediments are spread by continuous bend along the Tersk cost of White sea, in West Karelia and on Onega-Ladoga isthmus. They are composed of sand-gravel material with pebble lenses and layers. (Engineering Geology of the USSR, 1978)

Fluvioglacial sediments of valleys are represented by fine-grained and average grained sands with unconstant amount of gravel and pebble, which some-times can be removed by loams. The thickness of these sediments usually does not exceed 5 - 10 m. (Engineering Geology of the USSR, 1978)

Water tightness of fluvioglacial sands depends on their particle size's composition: for sands it is from 24 MPa to 48 MPa, for loams it is from 22 MPa to 35 MPa. Average value of internal friction coefficient for fine grained particles is 0.57, for coarse-grained is 0.64. (Engineering Geology of the USSR, 1978)

2.2.2.4 The sediments of local and regional proglacial lakes

They are visible across the territory of Karelia and in the west of Kola Peninsula. Sediments of the regional proglacial lakes (Baltic first and second) occupy large areas in Lake Ladoga and Lake Onega, as well as in adjoining depressions (valleys Shui, Vodla). In the composition of sediments clay and loam are dominated; sandy loams and sands have secondary importance and, as a rule, occupy the upper or lower parts of the section. Thickness of local lake sediments is measured in first meters of the regional proglacial lakes from 15 to 50 m. (Engineering Geology of the USSR, 1978)

Granulometric composition of lake-glacial sediments is generally characterized by considerable heterogeneity and a high content of silty fraction, which in conjunction with the textural features determines their easy soakness, blurness and strong freezing heave. Sandy-silty fractions of glacial clays consist mainly of quartz, clay - hydromicas, sometimes with a small admixture of kaolinite and montmorillonite. In the physical-chemical behavior clays have a low activity, their absorption capacity is rarely more than 10 - 12 mq-ekv per 100 g of dry rock. Physico-chemical properties of lake-glacial sediments depend on the conditions of sedimentation and diagenesis and are characterized by high volatility. Thus, in the whole region loam bulk density varies from 1.52 to 2.24 g/cm^3; bulk density of the skeleton - from 0.92 to 1.81; void ratio – from 0.50 to 1.90 g/cm^3. In clays these figures vary widely: 1.41 – 2.07, 0.72 – 1.64, 0.61 - 2.60 g/cm^3. Almost every periglacial lake is characterized by its data and therefore the assessment of building properties requires the individual approach. In a wide range indicators of deformation and strength properties of lake-glacial sediments are changed. The most favorable properties have sands. Thus, the overall deformation modulus of sand according to experienced stress on stamps is within 30 — 35 MPa, on the results of statistical probing (according to SN 448-72) within 15 — 27 MPa. (Engineering Geology of the USSR, 1978)

The results of dynamic probing indicate greater heterogeneity in degree of compressibility of sands, but the overall module of deformation in different sands in cross-section usually not less than 15 MPa. The values of the internal friction angle in sands, which were estimated according to static and dynamic probing, are 33 - 35 °. Sandy loams are characterized by higher compressibility. Thus, values of modulus of deformation in sandy loam are 12—15 MPa. The most diverse in compressive and strength parameters are loams and clays. With the depth the clay density is sharply reduced and correspondingly the compression is increased. The module of total clay deformation for the least compacted portion of the section does not exceed 1,5 — 6,5 MPa. (Engineering Geology of the USSR, 1978)

Thus, according to the rotational shear, the resistance of clay shear in the upper weathered zone ranges from 0.035 to 0.135 MPa, it falls below up to 0.002 - 0.004 MPa. The marked ability of clays demonstrates the need for use in the construction of buildings the upper weathered zone and not its removal, as sometimes in the construction practice is done. (Engineering Geology of the USSR, 1978)

2.2.2.5 Marine late glacial sediments

They include first Yoldia Sea sediments and as a result they were named "Yoldia". They are widespread in the North Ladoga and especially in the West Pribelomore, also are found in the valleys of the rivers on the Kola Peninsula. They usually occur on the surface and only sometimes overlap with modern marine and peat-bog formations. Their thickness varies from several meters to 10-15 meters. There is the predominant distribution of clays, less loams. Sandy differences occur at the base of the sections. (Engineering Geology of the USSR, 1978)

Clays are usually plastic, viscous, sticky. In nature openings during weathering they form columnar jointing and are dissected by cracks with depth up to 1 m. Thickness of the weathering zone reaches 3 - 3.5 m. (Engineering Geology of the USSR, 1978)

In the clay mineral composition is dominated hydromica and primary relict minerals - plagioclase and biotite. The absorption capacity of clay is high (up to 30 mg-eq per 100 g of rock). Compressibility of late glacial sea clays was studied only in the Kem district. According Lengidroproekt, for all differences high structural strength is characterized: in weathered clay zones it ranges from 0.004 to 0.006 MPa, in a less dense - from 0.003 to 0.005 MPa. (Engineering Geology of the USSR, 1978)

Yoldia clays have high natural moisture content and porosity. They are characterized by strong and non-uniform compressibility and low shear stability. In addition, they dramatically reduce the strength and deformation properties in violation of the natural structure. They prone to frost heave. (Engineering Geology of the USSR, 1978)

2.2.2.6 Holocene sea sediments

They are spread by a strip with width of 10 - 20 km along the modern coast region, coming onto the area along the river valleys. They make up modern terraces with thicknesses less than 10 - 15 m. (Engineering Geology of the USSR, 1978)

The consequence of poor compaction of clays is their high compressibility. The modulus of total deformation from 0.5 to 1.8 MPa. The few tests of sea clays in shear gave the following results: the angle of internal friction varies from 2 to 19°, and cohesion is 0.05 MPa. During the construction on sea clays of Holocene foundations on piles are applied. They bear on underlying moraine or crystalline rocks. (Engineering Geology of the USSR, 1978)

2.2.2.7 Holocene lake sediments

They are distributed along the shores of modern lakes, where they form lower parts of bank slopes, low terraces, beach ridges and beaches. Areas of their distribution are tent to be areas of lake-glacial sediments from which they not always can be separated. Sediment thickness varies from 0.5 to 5 m, rarely reaching 10 m or more. (Engineering Geology of the USSR, 1978)

The lithological composition is different: sands are dominated, sometimes gravel and pebbles, rarely sandy loam, loam, and in the coastal zone –gravel and boulder. The characteristic features of lake formations are horizontal layering, the presence of plant residues, and sometimes peat layers. Granulometric composition of lake sediments is varied. (Engineering Geology of the USSR, 1978)

There are small and medium sands dominated. They have a significant amount of silty fraction. A clay content of silty fractions in most cases exceeds 40%, sometimes reaching 90-95%. In the fine fraction of clay loams the hydromica is dominated. Often there is a high content of organic matter. (Engineering Geology of the USSR, 1978)

The module of total deformation of the lake clays varied from 0.4 to 230 MPa (mean 115 MPa), which indicates that they are extremely high compressibility. Values of shear strength are very low: angle of internal friction is 10°, cohesion is 0.0008 MPa. Tested by the method of rotational shear, the shear strength was also very low (0.013—0.014 MPa). (Engineering Geology of the USSR, 1978)

Assessing the quality of construction of lake sediments, it should be noted that the sands have satisfactory characteristics. But due to the high content of silt particles, they sometimes exhibit the properties of quicksand. (Engineering Geology of the USSR, 1978)

In addition, there are lenses and layers of compacted clay loams and clays in sands, which create a risk of uneven settlements. Clay lake sediments are characterized by very low strength, a large compressibility. (Engineering Geology of the USSR, 1978)

Thus, in construction pile foundations with end bearing piles and special methods of work production, excluding dynamic impact, are used.

2.2.2.8 Peat-bog formations of the Holocene

They are widespread on the territory of the region, occupying about 30% of its area. Their average thickness is 1 - 2 m, maximum is 10 m. Peat is brown. The degree of decomposition to a depth of 1.6 - 2 m is weak, deeper is average. (Engineering Geology of the USSR, 1978)

2.3 Baltic region

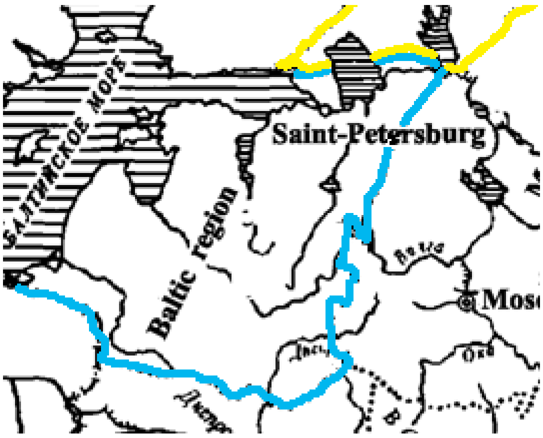

Figure 5 Baltic region (Geology of the USSR, 1971)

Figure 5 shows the geological region of Russian platform: Baltic region.

The most part of the region is occupied by glacial lakes and low-multi-temporal and marine abrasion and accumulative plains with an altitude of the surface from 0 to 100 meters. Only in the south and east boundaries some of the ridges and hills with elevations up to 342 m are traced. The largest of them is Valdai elevation which comes to the region by only north-western slope. Within this area there is a row of major platform structures: southern slope of the Baltic shield, the Latvian Saddle, the Belarusian-Lithuanian and eastern array, part of the Baltic syncline. (Engineering Geology of the USSR, 1978)

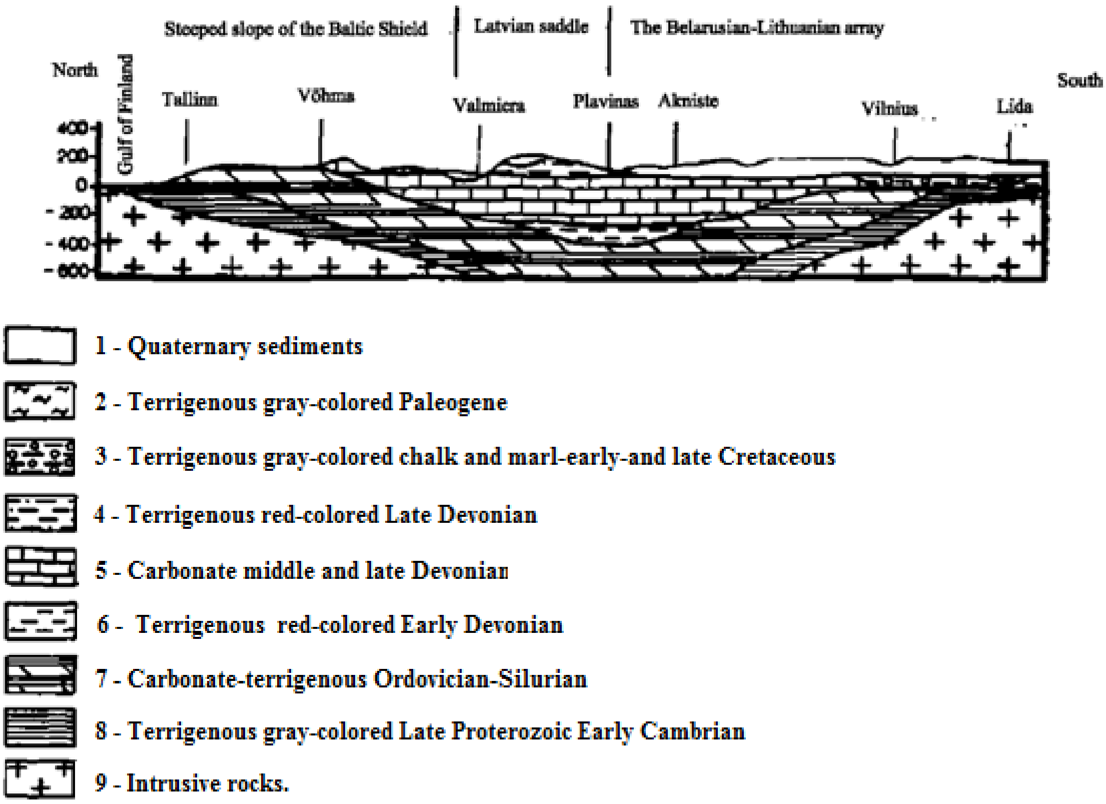

Figure 6 Schematic geological section of the Baltic region (Engineering Geology of the USSR, 1978)

Figure 6 shows Quaternary sediments (number 1) and Formations (numbers 2-9).

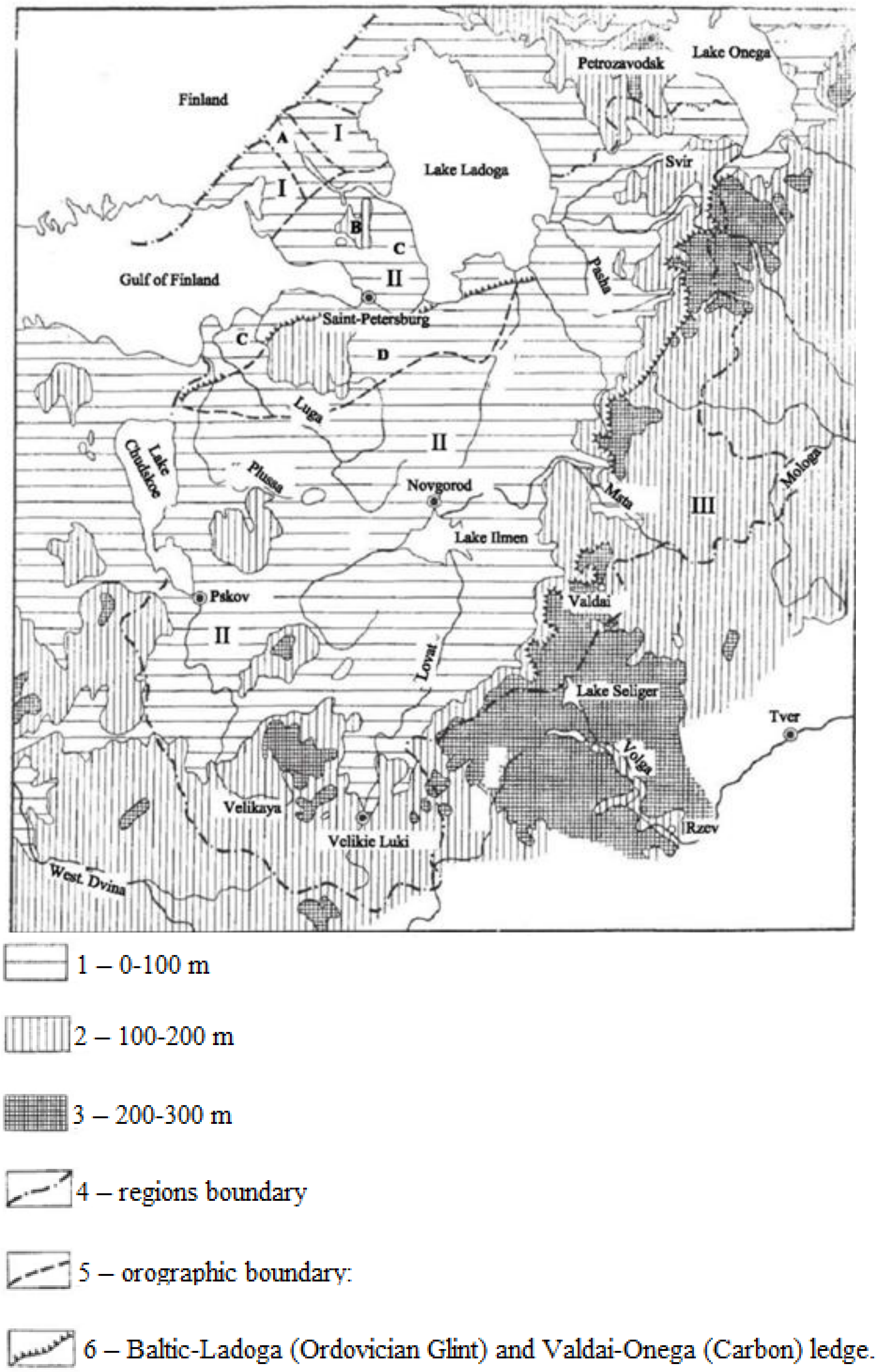

Figure 7 Hypsometric map of the Leningrad Region, Novgorod and Pskov regions (Engineering Geology of the USSR, 1978)

Figure 7 shows the absolute heights of territories. I – North of Karelian Isthmus, II – Baltic lowland, III - The Valdai Hills, A – Vuoksinskaya lowland, B – The central elevation of Karelian Isthmus, C – Predglintovaya lowland, D - Ordovician plateau, E - Devonian plain

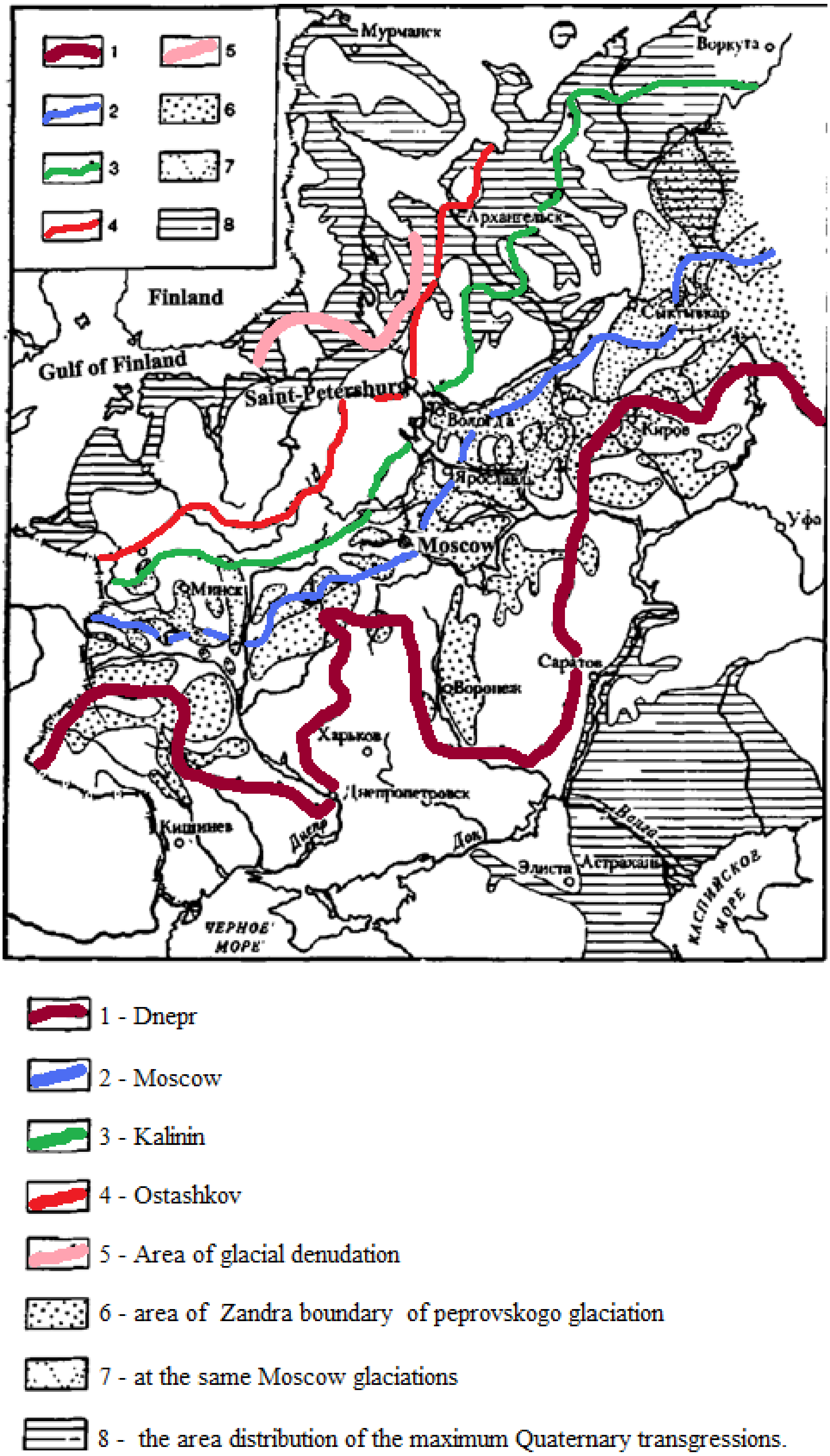

Figure 8 Scheme of distribution of continental glaciation, Middle Pleistocene Zandra boundary and Quaternary transgressions on the Russian platform (Engineering Geology of the USSR, 1978)

Figure 8 shows the boundaries of the spread of continental glaciations by numbers 1 - 8.

2.3.1 Vendian complex

Vendian complex combines the youngest divisions of the Upper Proterozoic. The absolute age of this complex is 560 - 650 million years. (Engineering Geology of the USSR, 1978)

On the Russian Platform the Vendian Complex is represented by Kotlin horizon.

Sediments of Kotlin horizon are absent only in the northern part of the Karelian Isthmus, within the considered territory. Under the Quaternary sediments Kotlin horizon is traced as a narrow strip, which is stretched along the southern coast of the Finland Gulf, in the southern part of the Karelian Isthmus, through Saint-Petersburg and it's outskirts. (Engineering Geology of the USSR, 1978)

The depth of Kotlin horizon increases from north to south. In the south-eastern direction from Baltic Shield to Moscow syncline the depth is 40 - 70 m. In the Predglintovoy lowland, the depth is 1250 m. Near the Valdai, the depth of Kotlin horizon is 1430 m. (Engineering Geology of the USSR, 1978)

Kotlin horizon is characterized by the comparative constancy of the section on this territory.
Kotlin horizon is represented by a monotonous thickness of dense clay, siltstone clay, which color is gray, greenish-gray and brownish. A characteristic feature of clay is a thin lamination, which is conditioned with a frequently alternation of argillaceous and siltstone partings through every 1 - 3 mm. Many brown films of fine-grained pyrite and organic inclusions exist on plain of bedding. (Engineering Geology of the USSR, 1978)

2.3.2 Baikal structural stage (Upper Proterozoic-Lower Cambrian)

It is composed by sand-clay formations. The greatest practical interest are laminoritovye clay of the Upper Proterozoic and blue clay of Lower Cambrian. (Engineering Geology of the USSR, 1978)

Laminaritovye clay is thin-layer (fissile), sometimes massive. Lamination of clay is not correct, small lenticular, there are layers and lenses of sands and weak sandstones. Clay is solid and dense. In appearance, physical and mechanical properties are close to rocky soil. (Engineering Geology of the USSR, 1978)

This Laminaritovye clay is widespread throughout the region, but in the zone of engineering impact is located only within Predglintovoy lowlands, at the depth of a few tens of meters. In the rest of the area the clay are located at depth of hundreds or thousands of meters under younger rocks. Thickness of clay varies from 20 - 45 meters in the northern Estonia up to 170 meters in the Leningrad Region. (Engineering Geology of the USSR, 1978)

Blue clay in most cases are laminated, which is defined by alterating layers of clay and sand with thicknesses from 1 to 2 mm, rarely massive clay with a uniform texture. There are layers and lenses of sandstone. (Engineering Geology of the USSR, 1978)

The consistency of Blue clay is tight plastic or semi-solid. Within Predglintovoy lowland, blue clay is located at the depth of 20 - 30 meters and occurs in the base of the Ordovician limestone cliff and in the valleys of the rivers. In the rest of the region clay occurs at big depth and does not have practical importance for construction. (Engineering Geology of the USSR, 1978)

Granulometric composition of laminaritovye and blue clays is very similar. The content of clay fraction in the blue clays usually ranges from 30 to 60%, and dusty fraction ranges 40 - 64%; the average content of clay fraction in laminaritovyh clay is 50%, dusty fraction is 45%, the amount of sand particles rarely exceeds 8 - 10%. The mineral composition of fine fractions of laminaritovyh clay is hydromicaceous, sometimes with an admixture of glauconite and kaolinite. Blue clay contains montmorillonite and hydromicas. (Engineering Geology of the USSR, 1978)

The physical properties: natural moisture content is 13 - 16%, all the moisture in the clay is physically bound.

Laminaritovye clay is moderately dilatation - the total dilatation does not exceed 10 - 11%. However, at the same time the value of dilatation can reach 0.105 MPa. (Engineering Geology of the USSR, 1978)

The dilatation for blue clay is about 27 - 30%. The moisture of dilatation for all the samples is near to plastic limit. (Engineering Geology of the USSR, 1978)

The modulus of deformation for Laminaritovye clay is 675 MPa, for blue clay it is 28 MPa. (Engineering Geology of the USSR, 1978)

The shear strength of blue clay with natural moisture content is as follows: the angle of internal friction 22°; the traction is 0.073 MPa. (Engineering Geology of the USSR, 1978)

All these data characterize the natural basis as a reliable base for engineering structures.

2.3.3 Caledonian structural stage (Ordovician-Silurian)

It is composed primarily of carbonate rocks and was formed under normal marine basin with rich organic life. Only the lower strata of Ordovician are presented by sandstones and shales. Ordovician sediments are widely distributed in the south of the limestone cliff and in the south and south-east under the Devonian sediments. Full thickness achieves 100 - 200 meters and increases from the south-eastern boundary of the region up to 300 meters. (Engineering Geology of the USSR, 1978)

Silurian sediments are developed in the western part of region. They appear on the surface in central part of Estonia and to the south and southwest are immersed to a depth of more than 0.5 kilometers. Thickness of Silurian sediments ranges from 12 to 957 m. (Engineering Geology of the USSR, 1978)

This formation consists mainly of limestone, dolomite and often clay. The composition varies from massive to thin platy, structure is changed from hidden-crystal to coarse crystal, sometimes there are organogenic clastic differences. (Engineering Geology of the USSR, 1978)

The physical properties of limestone and dolomite are close to each other. For Kingisepp and Narva Hydroelectric Station are obtained the average values: volume weight of rock is 2,54 - 2,58 g/cm^3; porosity is 8,6 — 9,8%; water absorbtion is 2,67 — 2,94%; air-dry compressive strength is 52.2 — 62.5 MPa, water-saturated compressive strength is 37.4 — 51 MPa. (Engineering Geology of the USSR, 1978)

The coefficient of frost resistance after 25 cycles of freezing is usually greater than 0.7 - 0.8, and the coefficient of softening, usually greater than 0.7. (Engineering Geology of the USSR, 1978)

With dipping layers in the south-east salinity increases rapidly (up to 3 g/l or more), water enriches with sulfates and sulfate and become aggressive towards concrete. (Engineering Geology of the USSR, 1978)

These sediments can serve as a reliable basis for the different structures.

2.3.4 Hercynian structural stage (Devonian)

It is composed by a variety of genesis and lithological composition of sediments. They can be divided into three formations: a lower terrigenous red-colored, formed in the early Devonian, carbonate lower classes and Frasnian stage and upper terrigenous-red-colored - the upper Frasnian and Famennian stages. (Engineering Geology of the USSR, 1978)

Formation of red terrigenous Early Devonian is presented by thick layers of sand with lenses and layers of clay, accumulated in the marshy plains. The lower part of the section is dominated by clay with interbedded marls and limestones with numerous inclusions of dolomite. The total thickness of sediments reaches 50 - 150 meters in region, they are located in the western parts of Lithuania and Latvia. (Engineering Geology of the USSR, 1978)

Formation of the Devonian carbonate is represented by carbonate-clay and sulfate rocks of Frasnian stage, and is spread significantly in the region (except for the northern region). These rocks are covered by Quaternary sediments capacity from a few meters to 200 meters. Formation of red terrigenous of Late Devonian is widely distributed within the Central Devonian field. These sediments occur at shallow depths and are often used as a basis for large industrial and energy facilities. (Engineering Geology of the USSR, 1978)

They form a thickness ranging from 200 to 600 m, declining to 30 - 40 m in the field of erosional scour. Sediments are frequently interbedded variegated clays, marls and sands of inconstant thicknesses. Clay rocks dominate in the formation and determine. (Engineering Geology of the USSR, 1978)

According to the engineering-geological evaluation they are sandy and calcareous. In the granulometric composition of clay the dust particles are dominated (typically greater than 50%), the content of clay particles varies from 10 to 40%, sand does not exceed a few percent. (Engineering Geology of the USSR, 1978)

Clay is well consolidated. The consistency of clay is semisolid, the coefficient of water saturation in most cases does not exceed 0.8 - 1.0. The modulus of deformation of clay is 20 – 70 MPa, the internal friction of clay is 13°, and cohesion 0.097 MPa. (Engineering Geology of the USSR, 1978)

The red clay's formation of late Devonian possesses satisfactory properties and can serve as a secure base for various engineering structures. (Engineering Geology of the USSR, 1978)

2.3.5 Upper Alpine structural stage (Pleistocene-Holocene)

It is composed of loose rocks. They appeared because of glaciers and their melt water. Pleistocene sediments are deposited on the eroded surface of the Pre-Quaternary rocks. They include a series of moraines of different ages (Oka, Dnieper, Moscow, Kalinin and Ostashkov) separated by moraine-sandy-clayey formations of variable composition and thickness. The total thickness of Lower, Middle and Upper Pleistocene sediments varies from 2 - 10 m, in some areas of Ordovik plateau and Predglintov lowland it can be up to 300 m or more in the preglacial valleys and in areas of marginal formations. On the surface they are covered with complex of post-glacial formations of different genesis with thickness up to several tens of meters. (Engineering Geology of the USSR, 1978)

The most widespread, the best known and most important from engineering-geological point of view are the Dnieper, Moscow, Kalinin and Ostashkov moraines. Thickness of individual moraine horizons unstable and varies from 1-3 to 40 - 50 m, reaching in the areas of end-moraine ridges 100 - 120 m. Moraines are composed by boulder loam, sandy loam, rarely by clays with layers and lenses of strip-clays, sands, gravels, pebbles and boulders. (Engineering Geology of the USSR, 1978)

With overall heterogeneity of size in granulometric composition moraine sediments are characterized by constant distribution of the individual fractions. Thus, in all moraines regardless of their age dust particles are much dominated with the content from 30 to 85%. Content of sand particles varies from 5 to 50, clay particles from 10 to 30, big inclusions from 5 to 20%. (Engineering Geology of the USSR, 1978)

For moraines a chaotic, breeding and sometimes comminuted texture is typical.

There are quartz with feldspar, hornblende and opaque materials in mineral composition of the coarse. The composition of fine fraction is homogenous. It is hydromicaceous with a small amount of fine-grained quartz and kaolinite. (Engineering Geology of the USSR, 1978)

Moraine loams have low exchange capacity (absorption capacity does not exceed 5 - 10 mg-eq per 100 g of rock). Moraine rocks are usually hard and semi-solid, rarely they are hard plastic and only in rare cases – easy plastic and fluid plastic. (Engineering Geology of the USSR, 1978)

Moraine sediments have moderate natural humidity (9.5 - 22%). Because of the heterogeneity and strong silty moraine sediments quickly soak (from several minutes to 2 - 5 days). They are prone to freezing heave. The coefficient of heave for moraine loams of Narva area, according to LISI, is 5 - 10%. Due to the large moraine compaction permeability is low. (Engineering Geology of the USSR, 1978)

Filtration coefficient for sands is measured by tenths, for sandy loam by hundredths, and for loams by thousandths of a meter per day. The average values of compressive modulus of total deformation are following: the loam from 10 to 15 MPa, the sandy loam - from 15 to 25 MPa, the sand - from 17 to 35 MPa. Values of total deformation module exceed in 1.5 - 2 times of compression, and sometimes in 3 - 4 times. Big influence on the compressibility of moraine sediments has their consistency. The average value of total deformation modulus for sandy loams of solid consistency has reached 45 MPa, and of plastic - only 25 MPa. Due to weathering of moraine sediments and different content of large inclusions, the large scatter of individual values of deformation modulus (from 12 to 90 MPa) can be explained. Ablation moraine is characterized by reduced values of deformation modulus. For sandy loams of Moscow moraine in Minsk region they are 6 – 9 MPa. In static test of solid rocks specific drag is 5 - 6 MPa, with the increase in individual interlayers up to 20 – 30 MPa; specific friction on the lateral surface of the probe at average is 0.008 – 0.01 MPa, the rocks of plastic consistency have 1.5 - 3 MPa and 0.003 – 0.004 MPa. Significant moraine compaction causes high shear resistance. For Ostashkov moraines this values are: clays - angle of internal friction of 16 - 25°, cohesion 0.003 – 0.005 MPa; loams have 24 - 28° and 0.002 – 0.007 MPa; in sandy loams is 27 - 33° and 0.015 – 0.06 MPa; in sand angle of internal friction is 33 - 37°, the parameter of linearity is 0.012 – 0.015 MPa. Moraines of another age have similar characteristics. Tests by the method of accelerated shifts lightly affect the results. (Engineering Geology of the USSR, 1978)

The main complicating factors in construction on moraine sediments are the heterogeneity of their composition and structure, susceptibility to frost heave, the presence of sand lenses and layers containing pressurized water. The waters are fresh, calcium bicarbonate usually non-aggressive. (Engineering Geology of the USSR, 1978)

2.3.5.1 Fluvioglacial and between moraine Late sediments

They are also widespread in the Baltic. Late Moscow and Late Ostashkov water-ice sediments, situated on the surface have big interest for the construction. They form zandrs, fluvioglacial deltas, marginal and radial eskers. Thickness of glaciofluvial sediments within zandr fields usually ranges from a meter up to 15 - 20 m, in esker ridges 20 - 25 m, rarely more. Their composition is very diverse (from pebble gravel to sandy-loam), but usually sands are dominated. They are characterized by high variability of composition along strike and in cross section. Sands of zaidr fields are usually middle-sized and small, often silty. There are the large-and medium-size sands in ozas. The addition of sands mostly middle tight. Water permeability of sands, depending on the grain size varies from few meters to several tens of meters per day. The compressibility of sands is weak. The overall deformation modulus of Ostashkov sands in most cases ranges from 21 – 37 MPa up to 50 – 60 MPa, at least up to 120 – 130 MPa. The total deformation module of Moscow sands in Byelorussia 0.014 – 0.088 MPa. (Engineering Geology of the USSR, 1978)

As a result of shear tests (the standard method), the angle of internal friction of sand in most cases 32-38° and the linearity parameter 0.01 – 0.02 MPa. (Engineering Geology of the USSR, 1978)

Clay lenses which are in layers of sands are characterized by content of dusty fraction (on average 40-55%). It causes a frost heave. They are characterized by medium dense, almost full water saturation. Consistency of sandy loams is plastic, loams - hard or soft plastic. The compressibility of clay formations is middle. The module of total deformation for sandy loams according to compression tests varies from 7 to 28 MPa (average of 10 MPa), for loams - from 10 to 16 MPa (average 11 MPa). (Engineering Geology of the USSR, 1978)

In general, fluvioglacial sediments have satisfactory building properties and may be a good basis for different engineering structures. (Engineering Geology of the USSR, 1978)

2.3.5.2 The sediments of local and regional glacial lakes of Late glacial age

They usually occur on Ostashkov moraine and only in some places overlap with a thin cover of Holocene sediments. Lake-glacial formations also have significant development. The thickness of regional lake sediment (first and second Baltic lake) is about 20 – 25 m, the local - 10 - 16 m. Maximum thickness of interstadial lake-glacial formations sometimes exceeds 40 - 50 m. (Pargolovo,Yukki). In the composition of sediments clays and loams are dominated and less frequently sandy loams and sands are encountered. A characteristic feature of sediments is their banded texture caused by the alternation of clay layers with silty layers. (Engineering Geology of the USSR, 1978)

Particle size of sediments is very heterogeneous - silts and very silty rocks (dust content up to 70 - 90%) are dominated. Very silty rocks together with textural features of rocks determine their susceptibility to frost heave. In the mineral composition of solid dispersed fractions quartz is dominated, and in fine - hydromica. In the areas of Pre-Quaternary carbonate rocks in belt clays up to 30% of carbonate is marked. (Engineering Geology of the USSR, 1978)

The absorption capacity often exceeds 10 - 30 mg-eq per 100 g of rock. Thickness of the lake - glacial sediments is characterized by high heterogeneity in density. (Engineering Geology of the USSR, 1978)

Belt sediments quickly soak. In the slopes after moistening belt sediments form landslides and streams. Filtration coefficient along the layers in hundreds-thousands of times is higher than across the layers. (Engineering Geology of the USSR, 1978)

Lake-glacial loams and clays have high compressibility and they are very heterogeneous. The effective load seldom reaches 0.04 – 0.06 MPa. For the same loads the overall deformation module of loams and belt clays of Leningrad region does not exceed 5 – 10 MPa, in Pskov and Novgorod regions – usually 7 - 11 MPa. Sandy loams and sands mostly have medium compressibility: modulus of total deformation for sandy loams of Leningrad region is 10 - 22.5 MPa. If natural structure of belt sediments is impaired the compressibility will increase by 2 - 3 times. Belt sediments even after pre-compaction have low shear strength. (Engineering Geology of the USSR, 1978)

For belt clays of Pskov and Novgorod regions following values are characterized: the angle of internal friction is 10 - 11°, cohesion 0.02 – 0.03 MPa. If the natural structure of belt clays is impaired, shear resistance will fall. Structural strength has reversible (thixotropic) character. In conclusion, it should be noted that loamy sand, belt loams and clays of interstadial and partly of local late glacial lakes (Pskov and Novgorod, Lithuania) can be a satisfactory base for most civil engineering structures. (Engineering Geology of the USSR, 1978)

Band clays and loams of regional glacial lakes are more weak rocks in construction. In the design of bases and erection on them strip foundations it is necessary to restrict specific loads in the range 0.01 — 0.015 MPa. During the construction on belt clays with low thickness it is expedient to use end bearing pile base, which is rested on the moraine or pre-Quaternary rocks. (Engineering Geology of the USSR, 1978)

2.3.5.3 Sea post-glacial sediments

They include formation of second Yoldia, Ancylus, Litorina and, mussel and limniev stages of Baltic Sea and also underlying more old first Yoldia Sea sediments. Last makes before-Holocene cavity of Baltic Sea and are characterized by presence in the cross section of sandy silts (fraction of the dust more than 50%). They form a layer with thickness from 1 to 16 m and usually are covered by younger formations. (Engineering Geology of the USSR, 1978)

Deposits of second Yoldia Sea can be seen along the shores of Baltic Sea at elevations ranging from -7 to +50 m and lie on the surface or lie at a depth of 4 m. Their thickness rarely is more than 3 - 5 m. Yoldia sediments are presented by loams, rarely by clays, sometimes by peats at the bottom. Granulometric composition of formations varies widely: the presence of clay fraction 10 - 50%, sity fraction 40 - 75%, sandy fraction 0 - 40%. (Engineering Geology of the USSR, 1978)

Ancylus Lake sediments are deposited on the eroded surface of previous basin sediments. Thickness of sediments rarely exceeds 2 - 3 m. At the depth of 1 - 3 m they are represented with small and silty sands, at the base – big sands. Sandy loams and loams with plant residues (from 1/2 to 26%) are rarely found. In the thick alluvial peat with thickness of 0.3 - 0.5 m is traced. Litorina Sea sediments in various parts of the coast make up the lowest abrasion-accumulative terrace with altitudes of 5 - 27 m. Maximum thickness is 12 - 15 m. They are represented by sands, sandy loams, loams and clays. All rocks are humified with large contain of plant residues and vivianite inclusions. (Engineering Geology of the USSR, 1978)

In this column can be traced a peat horizon with thickness up to 1 m. In the coastal strip of Litorina Sea gravel-pebble formations with irregular and diagonal bedding can be met. In granulometric composition, Litorina sediments are reresented by silts. There are 30 - 50% particles with size 0.05 - 0.005 mm. (Engineering Geology of the USSR, 1978)

The youngest sediments of mussel and limpnev stages can be traced on the beach ridges along the coast of Estonia and the Gulf of Finland. They are represented by middle grain size and coarse sands with lenses of sandy loams, loams and clays. Their thickness is 1 - 3 m. (Engineering Geology of the USSR, 1978)

Physical properties of considered sediments show a significant inhomogeneity of rocks. For sands it is characterized middle dense addition. Argillaceous rocks are saturated with water and sand rocks - aquifer. Due to the large dusty almost all considered rocks are prone to frost heave. The most unfavorable construction properties have Litorina sandy loams, loams and clays. Strong and very strong compressibility is show also by total deformation modulus according to the compression tests under the same loads. In sands and sandy loams with low organic content the total deformation modulus is 9 MPa. In peats the total deformation modulus is 0.5 - 1 MPa. Rocks are characterized by low shear resistance. (Engineering Geology of the USSR, 1978)

From the constructional point of view complex sediments are classified as weak and building erection on such sediments is not regulated by building codes. The only exceptions are sands without plant remains which can be a satisfactory base for different structures. (Engineering Geology of the USSR, 1978)

2.3.5.4 Alluvial Upper Pleistocene and Holocene sediments

They are located within river valleys and contain sediments of the flood plain and flood plain terrace. (Engineering Geology of the USSR, 1978)

It is presented by channel, floodplain and oxbow facies. In the channel alluvium the thicknesses of which are from 0.5 to 20 meters the fragmental difference dominates. Floodplain alluvium is characterized by the development of sand, sandy loam, loam and clay with some coarse fragmental material. (Engineering Geology of the USSR, 1978)

The medium dense sand rarely dominates. The coefficient of relative density of the Holocene alluvial sand, depending on their composition varies from 0,25 - 0,27 (small and dusty) to 0,34 - 0,43 (medium and large size), while the Upper Pleistocene sands are usually 0,49 - 0,55. Compressibility of the alluvial sand is low or middle. (Engineering Geology of the USSR, 1978)

The sandy alluvial sediments have satisfactory strength and deformation properties and can serve as a good natural base for most of industrial and civil buildings. The coefficient of filtration of Alluvial sand varies from 0.1 to 20 m/day, due to inconsistency of their size distribution and different contents of clay particles. Therefore the water abundance of sand is extremely uneven. The waters are fresh, hydrocarbonate. (Engineering Geology of the USSR, 1978)

The alluvial clay sediments often contain organic debris and have a high humidity to 120%. The consistency of clay sediments varies from soft plastic to the fluid, less tight plastic. The values of the modulus of deformation (in compression tests) is low even among varieties with low content of organic material: for clay is from 3 to 10 MPa, for loam is from 5 to 11 MPa; the angle of internal friction is 15 – 20°, the traction varies from 17 to 20 kPa for sandy loam, 25 to 47 kPa for clay. If the content of organic materials is significant about 10-30%, the internal friction angle reduces, approximately 3 - 5°, but the cohesion stays within 0.015 – 0.025 MPa. (Engineering Geology of the USSR, 1978)

Use of the alluvial clay as a natural base usually requires the use of special types of foundations or implementation of reclamation measures. (Engineering Geology of the USSR, 1978)

2.4 Table with soil characteristics of all represented sediments of Baltic Shield and Baltic region

Appendix 4: Figure 1

Figure 1 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments of Baltic Shield.

Appendix 4: Figure 2

Figure 2 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments of Baltic Shield and the characteristics of Upper Proterozoic's, Upper Proterozoic – Lower Cambrian's, Ordovican – Silurian's and Devon's sediments of Baltic region.

Appendix 4: Figure 3

Figure 3 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments of Baltic region.

Appendix 4: Figure 4

Figure 4 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments of Baltic region.

2.5 The comparative analysis of the archive data and the geology investigation's data of specific building sites

To improve archive soil characteristics of the represented sediments two building sites with data after geology investigations were taken.

2.5.1 Geology data of the first building site

2.5.1.1 View of the first building site on the map

The first building site (the 25-stored building with underground parking) is situated in the northern part of Saint-Petersburg.

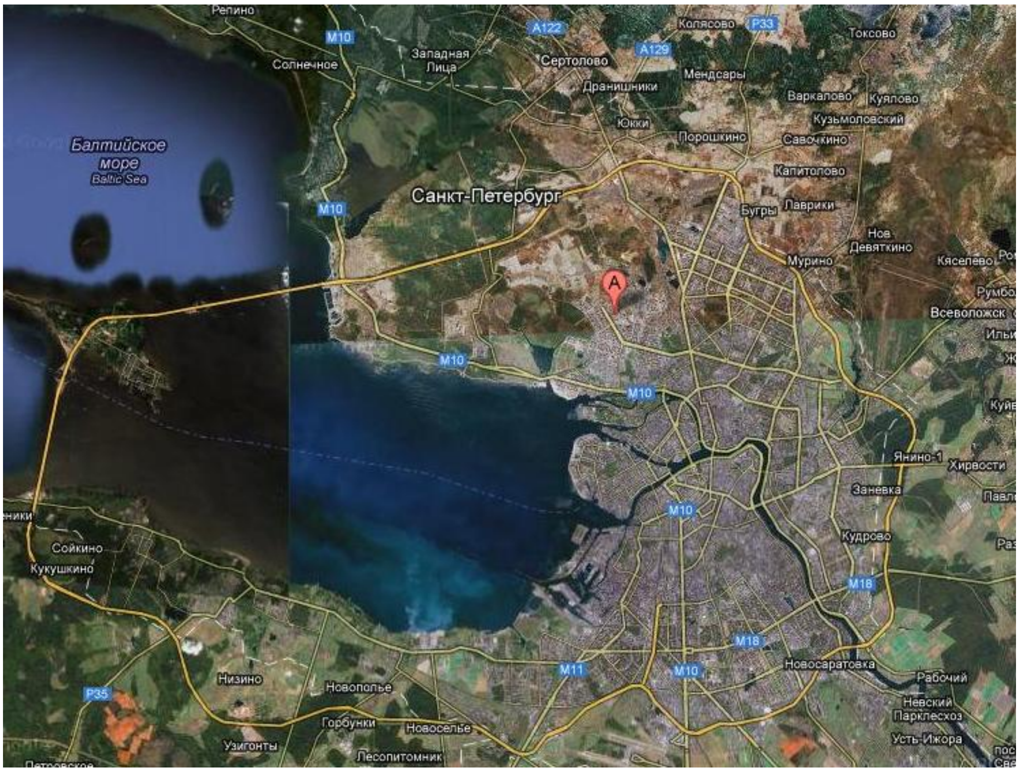

Figure 9 Map of Saint-Petersburg area and partly Leningrad region (Google maps. http://maps.google.ru)

Figure 9 shows the map of Saint-Petersburg city. In its northern part by red mark with letter “A” the studied building site is shown.

2.5.1.2 Physical and geographical conditions of a building site

The considered site is located in Primorsky region on made-up inwashed territory in the district 26A of Long Lake region on Koroleva prospect 46. Absolute marks of development mouths are 4.6 – 4.4 m. (Materials of geotechnology centre at SPSUACE, 2011)

2.5.1.3 Geological structure

In geological structure of a territory within a drilling depth of 35.0 m Quaternary sediments overlie on Upper Proterozoic (V kt2) sediments. Quaternary sediments are represented by modern sediments - technogens (t Q

IV), nutrients (b Q IV); Upper Quaternary sediments of Ostashkov horizon - lake-glacial (lg Q III lz) and glacial of Luga stage (g Q III lz); mid-Quaternary sediments of Moscow horizon - glacial (g Q II ms).
They are shown on drawings of geological columns №5333 and №5335 (Appendix 1: Figure 1) and (Appendix 2: Figure 1). (Materials of geotechnology centre at SPSUACE, 2011)

Figure 1 in appendix 1 shows on the right part of drawing the cross-section of the hole №5333 with thicknesses of geological sediments, their bottom depth, absolute marks, geological age and with what soils they are represented. Also it shows where samples were taken and the water level. The left part of the drawing in figure 1 in appendix 1 shows the results of static sounding test.

Figure 1 in appendix 2 shows on the right part of drawing the cross-section of the hole №5335 with thicknesses of geological sediments, their bottom depth, absolute marks, geological age and with what soils they are represented. Also it shows where samples were taken and the water level. The left part of the drawing in figure 1 in appendix 2 shows the results of static sounding test.

These columns are shown on a general plan of geological holes, which were done during geological investigations (Appendix 3: Figure 1). (Materials of geotechnology centre at SPSUACE, 2011)

Figure 1 in appendix 3 shows the building site with the situation of holes for geological investigations.

2.5.1.3.1 Pleistocene-Holocene's modern sediments

Technogen sediments are top and alluvial soils. Top soil IGE 1 with the thickness of 0.8-1.3 m is represented by sand with fragments of bricks, distributed till absolute marks of 3.7-3.3 m.
Alluvial soils IGE 1.1 are represented by gray silty wet sands, extended till absolute marks of 1.6 - 1.4 m. The thickness of alluvial soils is 1.7 - 2.2 m.

Biogenic sediments (b Q IV) are represented by water-saturated low peated soils IGE 2 with the thickness of 0.3-0.5 m. Biogenic sediments are distributed till absolute marks of 1.3-0.9 m. (Materials of geotechnology centre at SPSUACE, 2011)

2.5.1.3.2 Pleistocene-Holocene's Upper-Quaternary sediments of Ostashkov horizon

Lake-glacial Luga sediments (lg Q III lz) are represented by silty gray-brown sands with layers of dense sandy loam saturated with water IGE 3 with thickness 2.7-7.5 m. Sand's bottom was gone through at depths of 6.2 - 10.8 m, absolute marks are - 1.8 or -6.2m. Glacial sediments of Luga stage (g Q III lz) are represented by plastic – gray sandy loams (property soft and hardplastic) - IGE 4 and IGE 5. The bottom was gone through at depths from 13.9 to 15.3 m, at absolute marks - 9.5 or -10.8 m. (Materials of geotechnology centre at SPSUACE, 2011)

After comparative analysis it was set that Lake-glacial Luga sediments (lg Q III lz), which belong to Pleistocene-Holocene → the sediments of local and regional glacial lakes of Late glacial age → the sediments of regional glacial lakes and represented by silty gray-brown sands with layers of dense sandy loam have approximately the same characteristics as sandy loam and loam in archive table.

These compared characteristics of soils from the archive data and the building site are shown in appendix 4: figure 3 and appendix 4: figure 5 respectively and marked by green color.

Also it was set that Glacial sediments of Luga stage (g Q III lz), which belong to Pleistocene-Holocene → Glacial sediments of Karelian age and are represented by plastic – gray sandy loams have approximately the same characteristics as moraine sand, moraine sandy loam and moraine loam.

These compared characteristics of soils from the archive data and the building site are shown in appendix 4: figure 1 and appendix 4: figure 5 respectively and marked by gray color.

2.5.1.3.3 Pleistocene-Holocene's Middle-Quaternary sediments

Glacial sediments of Moscow horizon (g Q II ms) are represented by solid brownish-gray sandy loams IGE 6, hard silty brown sandy loams with gravel, pebbles, boulders IGE 7, silty solid light grayish-brown loams (property semi-solid) IGE 8. The bottom of sediments was gone through at the depth of 24.5 - 24.8 m., absolute marks are -20.5 and -20.8 m. The thickness of sediments is 9.4-9.5 m. All glacial sediments contain inclusions of gravel and pebbles, pieces of sandstone. (Materials of geotechnology centre at SPSUACE, 2011)

After comparative analysis it was set that Glacial sediments of Moscow horizon (g Q III ms), which belong to Plestocene-Holocene → Glacial sediments → Moscow moraine and represented by solid brownish-gray sandy loams, hard silty brown sandy loams with gravel, pebbles, boulders and silty solid light grayish-brown loams have approximately the same characteristics as loam and sandy loam in archive table.

These compared characteristics of soils from the archive data and the building site are shown in appendix 4: figure 3 and appendix 4: figure 5 respectively and marked by blue color.

2.5.1.3.4 Upper Proterozoic's sediments

Kotlin sediments (V kt2) are represented by silty solid bluish-gray clays IGE 9 dislocated and IGE 10 non-dislocated. They were gone through by 35 m wells to the absolute mark -31.0 m. The thickness of clays is 10.2-10.5 m. Engineering-geological section is presented in the columns of wells. (Materials of geotechnology centre at SPSUACE, 2011)

After comparative analysis it was set that Kotlin sediments (V kt2), which belong to Upper Proterozoic ⟶ Vendian complex (Kotlin horizon) and represented by dislocated and non-dislocated silty solid bluish-gray clays have approximately the same characteristics as clay in archive table.

These compared characteristics of soils from archive data and building site are shown in (Appendix 4: Figure 2) and (Appendix 4: Figure 6) respectively and marked by yellow color.

2.5.1.3.5 Hydrogeological conditions

In consideration of hydrogeology the building site is characterized by presence of ground water with a free surface of technogen, nutrient and lake-glacial sediments. Glacial sandy loam of Luga stage is aquitard. (Materials of geotechnology centre at SPSUACE, 2011)

2.5.1.4 Table with soil characteristics of represented sediments of the first building site

Appendix 4: figure 5

Figure 5 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments on a building site.

Appendix 4: figure 6

Figure 6 in appendix 4 shows the characteristics of Upper-Proterozoic's sediments on a building site.

2.5.2 Geology data of the second building site

2.5.2.1 View of the second building site on the map

The second building site (the railway station) is situated in the eastern part of Saint-Petersburg.

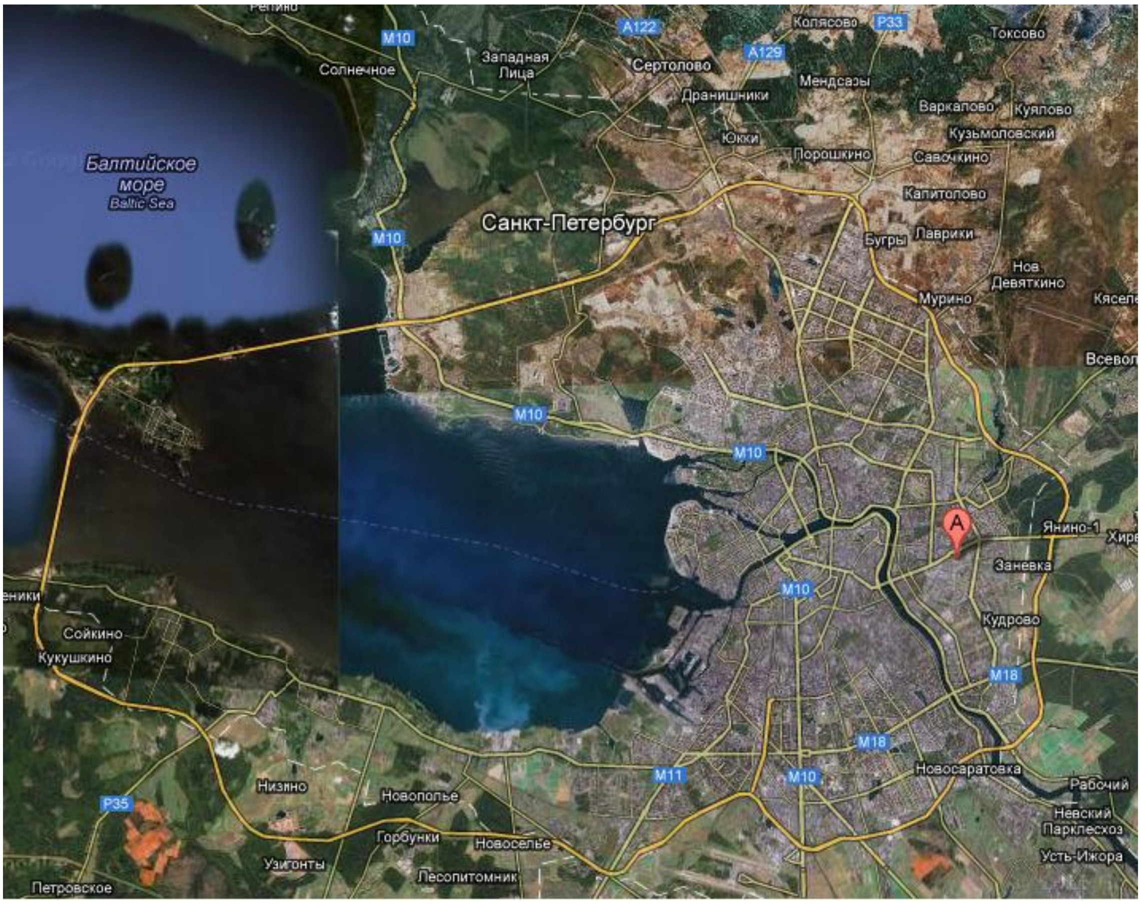

Figure 10 Map of Saint-Petersburg area and partly Leningrad region (Google maps. http://maps.google.ru)

Figure 10 shows the map of Saint-Petersburg city. In its eastern part by red mark with letter “A” the studied building site is shown.

2.5.2.2 Physical and geographical conditions of a building site

The considered site is located in Krasnogvardejskij region, Zanevsky prospect 73, on bogs territory with peat, which thickness is 1-2 m. Absolute marks of the surface are 5 – 8 m. In the period of time from 2002 to 2006 years on the bog sediments rubbish dump of technogenic soil was founded. (Materials of geotechnology centre at SPSUACE, 2011)

2.5.2.3 Geological structure

The geological structure of the second building site is represented by modern technogenic soils (t Q IV), which make up the body of the railway embankment modern biogenic sediments (b Q IV), occurring locally under the technogenic soils; modern marine and lake sediments (m, l Q IV); and Upper lake-glacial sediments (lg Q III) of Baltic Ice Lake, which are laid under the thickness of modern sediments

Modern technogenic sediments (t Q IV) along the rails are represented by granite gravel with the thickness of 0.2 - 0.4 m and fine – average-coarse sands with gravel and pebbles with the thickness of 1 - 2 m. (Materials of geotechnology centre at SPSUACE, 2011)

The soil in dumps is represented by fine sand and hard plastic loam with fragments of brick and concrete. The thickness of technogenic soil in dumps is 2 – 3 m. (Materials of geotechnology centre at SPSUACE, 2011)

Modern biogenic sediments (b Q IV) are represented by black water-saturated peat. On the most part of territory the peat lies under the technogenic sediments. The thickness of peat under technogenic sediments is 0.3 to 0.7 m. (Materials of geotechnology centre at SPSUACE, 2011)

Modern marine and lake sediments (m,l Q IV) are represented by fluid sandy loam and plastic, gray, very peated, with thin layers of sand and lenses of silty sand, loam and mineralized peat. The sand is silty, gray, peated and water-saturated. Loam is silty, light, dark gray and peated. Mineralized peat is black, dense and water-saturated. The sediments are spread within all territory of the technical station. Soils are thixotropic. The thickness of sediments is from 1.9 to 2.3 m. (Materials of geotechnology centre at SPSUACE, 2011)

Upper lake-glacial sediments (lg Q III) are represented by gray silty loam with thin layers of sandy loam and water-saturated silty sand. The thickness of lake -

glacial sediments is more than 3.0 m. (Materials of geotechnology centre at SPSUACE, 2011)

After material processing and laboratory studies there were identified 10 engineering-geological elements (IGE). (Materials of geotechnology centre at SPSUACE, 2011)

2.5.2.3.1 Pleistocene-Holocene's modern sediments

Pleistocene-Holocene's modern sediments are represented by modern technogenic sediments (t Q IV), modern biogenic sediments (b Q IV) and modern morine and lake sediments (m,l Q IV). (Materials of geotechnology centre at SPSUACE, 2011)

Modern technogenic sediments are represented by IGE-1, IGE-1b, IGE-2a, IGE-2b.

IGE-1a is fine crushed granite (3-5 cm). The thickness of crushed granite is up to 0.4-0.5 m. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-1b - wet yellow-brown gravelly sand with medium-density. The thickness of sand is 0.2-0.6 m. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-2a is wet, water-saturated light-brown fine sand of medium density. The thickness of sand is 0.4-1.1 m. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-2b is wet dark-gray and dark brown fine sand of medium density with inclusions of loam, crushed rock and building rubbish. The thickness of sand is 2.0 m. Due to the variability of the composition the normative values of the physico-mechanical characteristics of a given element are not shown. (Materials of geotechnology centre at SPSUACE, 2011)

Modern biogenic sediments are represented by IGE-3. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-3 is black, dense and water-saturated peat. Shear strength is 0.030 MPa. The thickness is 0.3 - 0.7 m. (Materials of geotechnology centre at SPSUACE, 2011)

Modern sea and lake sediments are represented by IGE-4 and IGE-5. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-4 is dark gray, very peated sandy loam with layers of water-saturated silty sand, loam and mineralized peat. Soils are thixotropic. The thickness is 1.9 - 2.3 m. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-5 is plastic, gray peated sandy loam without inclusions. The thickness is 1.5 m. (Materials of geotechnology centre at SPSUACE, 2011)

After comparative analysis it was set that modern sea and lake sediments (m,l Q IV), which belong to Pleistocene-Holocene → sea post glacial sediments and represented by dark gray, very peated sandy loam with layers of water-saturated silty sand, loam and mineralized peat and by gray peated sandy loam without inclusions have approximately the same characteristics as sandy loam of Ancylus and Litorinal Sea in archive table.

These compared characteristics of soils from the archive data and the building site are shown in appendix 4: figure 4 and appendix 4: figure 6 respectively and marked by red color.

2.5.1.3.2 Pleistocene-Holocene's Upper-Quaternary sediments

Pleistocene-Holocene's Upper-Quaternary sediments are represented by lake glacial sediments (lg Q III). (Materials of geotechnology centre at SPSUACE, 2011)

Lake glacial sediments are represented by IGE-6, IGE-7, IGE-8.

IGE-6 is gray, heavy and thixotropic silty clay loam. The thickness is up to 2.0 m. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-7 is dark - gray and gray, thixotropic silty loam. The thickness is more than 3.0 m. (Materials of geotechnology centre at SPSUACE, 2011)

IGE-8 is gray and light-gray silty loam with thin layers of water. The thickness is more than 3.0 m. (Materials of geotechnology centre at SPSUACE, 2011)

After comparative analysis it was set that Lake-glacial sediments (lg Q III), which belong to Pleistocene-Holocene → the sediments of local and regional glacial lakes of Late glacial age → the sediments of regional glacial lakes and represented by gray, heavy and thixotropic silty clay loam, dark - gray and gray, thixotropic silty loam and gray and light-gray silty loam with thin layers of water have approximately the same characteristics as loam in archive table.

These compared characteristics of soils from the archive data and the building site are shown in appendix 4: figure 5 and appendix 4: figure 7 respectively and marked by green color.

2.5.1.4 Table with soil characteristics of represented sediments of the second building site

Appendix 4: figure 6

Figure 6 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments on a building site.

Appendix 4: figure 7

Figure 7 in appendix 4 shows the characteristics of Pleistocene-Holocene's sediments on a building site.

3 DESCRIPTION OF CHOSEN FOUNDATION

After geology description of the region and comparative analysis of the characteristics the goal was set on the example of a specific building to describe a foundation method, which is suitable for geological conditions in the region and to make analysis of its advantages and disadvantages.

For the specific building site, Saint-Petersburg building site was chosen, because SPSUACE gave materials only with Saint-Petersburg building objects.

3.1 View of a building site on the map

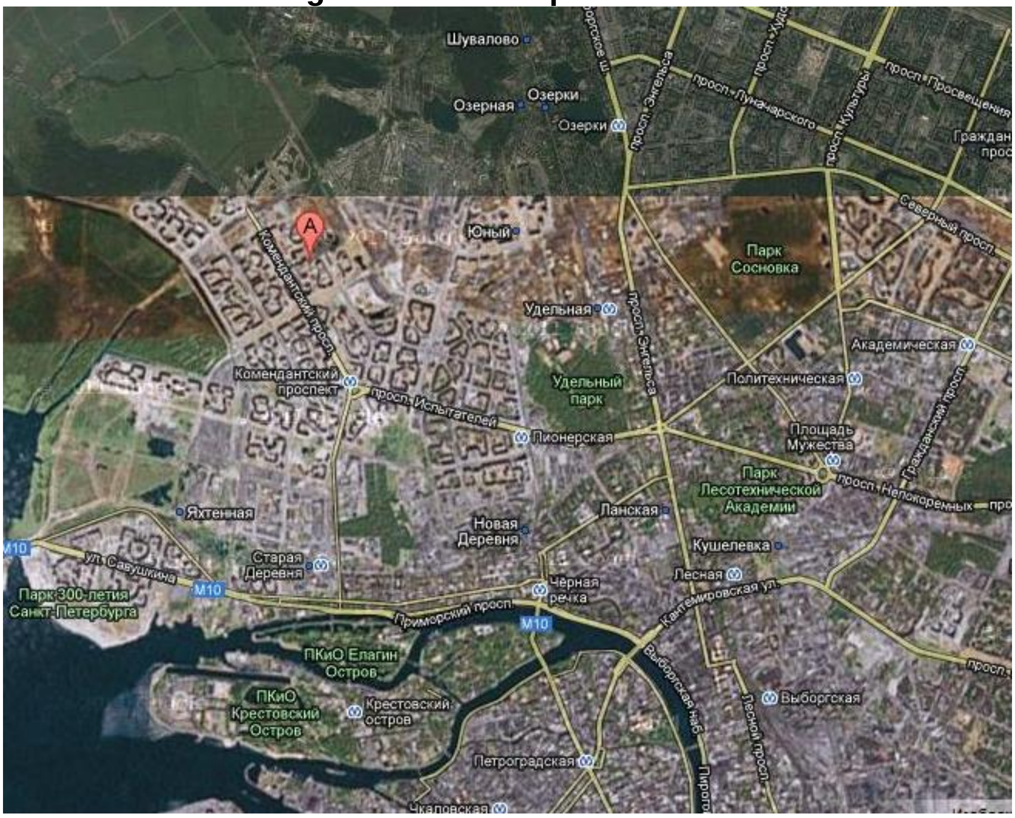

Figure 11 Zoomed northern part of Saint-Petersburg (Google maps. http://maps.google.ru)

Figure 11 shows the map of northern part of Saint-Petersburg with the building site shown by red mark with letter “A”.

Figure 12 Final zoom of the building site (Google maps. http://maps.google.ru)

Figure 12 shows the district where the building site is situated. The building site is marked by a square of red color. The construction object is situated in conditions of dense development.

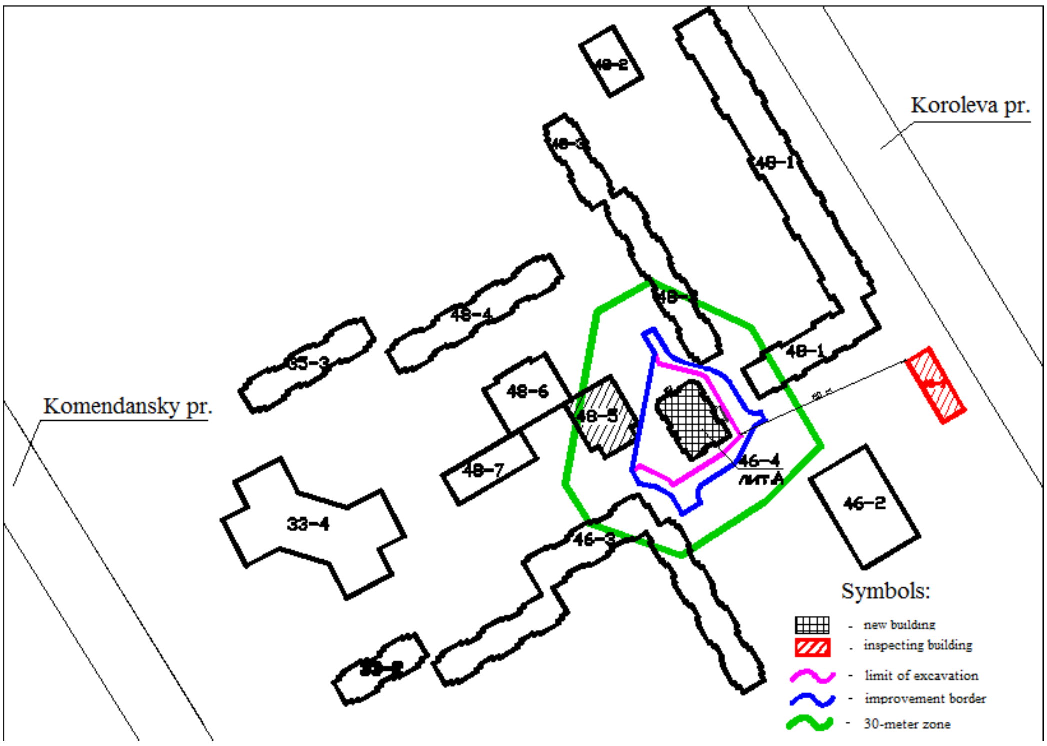

Figure 13 Location of the building site (Materials of geotechnology centre at SPSUACE, 2011)

Figure 13 shows a location of a new building colored by black net. Pink line – it is a limit of excavation. Blue line – it is improvement border. Green line – it is 30-meter zone (it is necessary to know if other buildings are in this zone to protect them from damage during construction and against settlements during maintenance of construction building, when it will have its own settlements).

3.2 Description of the building

Apartment house with a closed parking (25 storeys + underground parking area). (Appendix 5: figure 1)

Figure 1 in appendix 5 shows the drawings of the building facades in different axes with heights and dimensions.

For this building the pile type of foundation was chosen. It is the most suitable type of foundation for oversaturated and weak soils as described region has from the economical view and consumption of the material. For this building bored piles were chosen because of available apartment buildings, which are too close to the building site.

3.2.1 Design scheme of the building and calculation of foundation (pictures with design loads of each pile) using figures from calculation complex SCAD

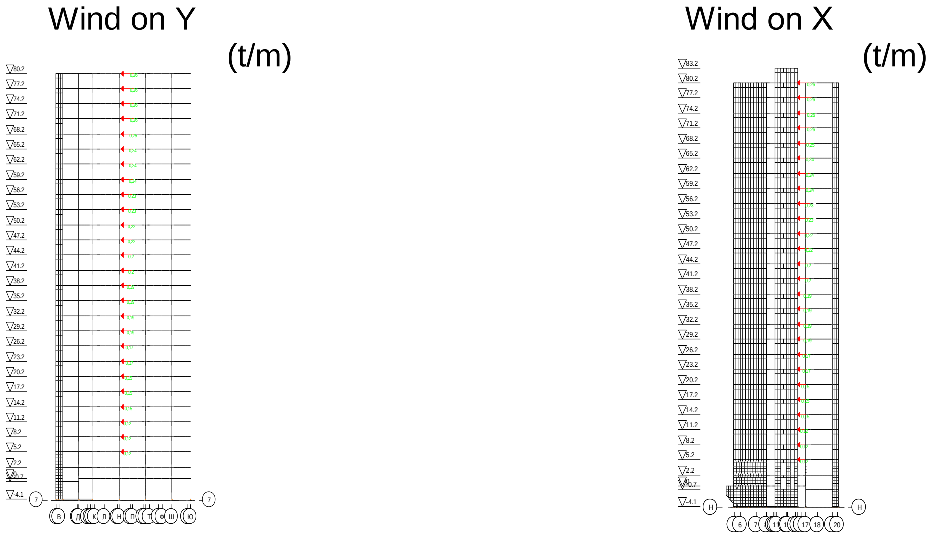

Figure 14 Design scheme of the building with applied temporary load: wind load on X and Y (Materials of geotechnology centre at SPSUACE, 2011)

Figure 14 shows the design scheme of the building, which was used in calculations in SCAD to know the loads on piles. After constant loads and temporary loads are applied to the design scheme in SCAD, by different combinations of constant loads and one or few temporary loads the distribution of loads on piles can be gotten.

Constant loads are dead weight, concrete screed, exterior walls, internal walls, lift, staircases and ventilation.

Temporary loads are wind on X and Y, payload (weight of people, equipment), wind pulsation on X and Y.

By combinations of constant loads with one of five temporary loads efforts on piles are gotten. (Materials of geotechnology centre at SPSUACE, 2011)

Appendix 6: figure 1

Appendix 6: figure 2

Appendix 6: figure 3

Appendix 6: figure 4

Appendix 6: figure 5

Figure 1 in appendix 6 shows the efforts on piles, which were gotten in SCAD in combination 1.

Figure 2 in appendix 6 shows the efforts on piles, which were gotten in SCAD in combination 2.

Figure 3 in appendix 6 shows the efforts on piles, which were gotten in SCAD in combination 3.

Figure 4 in appendix 6 shows the efforts on piles, which were gotten in SCAD in combination 4.

Figure 5 in appendix 6 shows the efforts on piles, which were gotten in SCAD in combination 5.

The results of these calculations were analyzed and the maximum loads of each pile in different combinations were taken into calculations of piles (length, cross-section and dimensions of grillages).

3.3 Chosen foundations

For this building pile foundations and foundations on a natural basis were chosen. The drawing appendix 7: figure 1 shows the pile field and foundations on a natural basis for columns. (Materials of geotechnology centre at SPSUACE, 2011)

Figure 1 in appendix 7 shows the situation of pile foundations with their dimensions, foundations for columns and location of wall in the ground.

For piles were chosen bored piles 450/560 with a diameter of 450 mm made of concrete B25 with the average strength 327 kg*f/sm2, W6 (watertightness 6 atmospheres) and F100 (frost-resistance 100 cycles). Termination of pile in grillage is rigid. (Appendix 8: Figure 1) (Materials of geotechnology centre at SPSUACE, 2011)

Figure 1 in appendix 8 shows a foundation on natural bases for column 900x900 mm with its dimensions and loads acting on it.

3.4 Methods used for bored piles

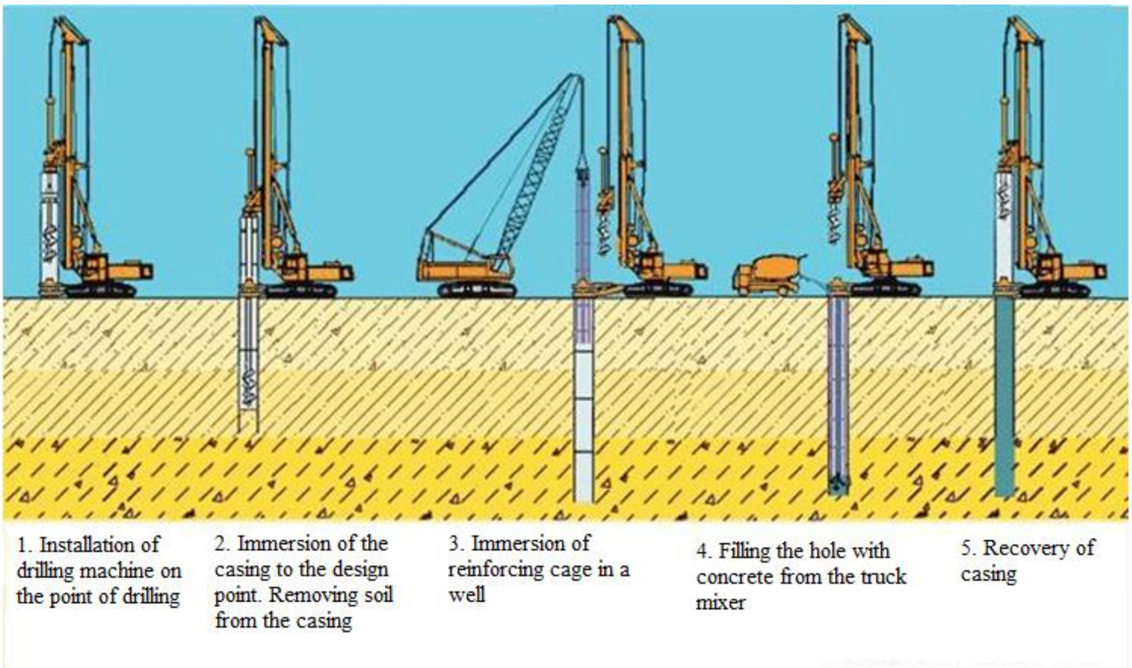

Figure 15 Methods used for bored piles installation

Figure 15 shows the technology process used for bored piles. The first step is installation of drilling machine on the point of drilling. Then it is immersion of the casing to the design point and removing soil from the casing. The third step is immersion of reinforcing cage in a well. The fourth step is filling the hole with concrete from a mixer. And finally, it is recovery of casing. (Bored piles. http://woodom.info/services/fundament/burenie-svay/info/tehnologii-burenia/)

A characteristic feature of bored piles technology is pre-drilling of wells till the desired mark and the subsequent formation of the pile shaft. (Bored piles.
Depending on soil conditions bored piles are set with one of three ways: without wall fixing holes (dry method), using the mud to prevent the collapse of wall or with fixing holes by liners. (Bored piles. http://woodom.info/services/fundament/burenie-svay/info/tehnologii-burenia/)

Dry method is applicable to stable soils (subsiding and clay solid, semi-solid and hard plastic consistency), which can keep the holes wall. Technology of such piles is following: by rotary methods of drilling hole of required diameter and at given depth is drilled in soil. After the hole is done if it is necessary reinforcement cage is mounted and after that by vertically moving pipe the hole is concreted. Used in the construction concrete pour pipes usually consist of separate sections and have joints for quick connection. In the hopper the concrete mix is fed directly from auto concrete mixer or with a special hopper. As concrete layer is laid, the concrete pouring tube is removed from the well. In a well the concrete mix is compacted with vibrators. By this technology bored piles with diameters 400, 500, 600, 1.000 and 1.200 mm and length of 30 m are most often manufactured. (Bored piles. http://woodom.info/services/fundament/burenie-svay/info/tehnologii-burenia/)

Clay mud to keep the walls from collapsing is used in bored piles in unstable watered soils. In this case the wells are drilled by rotational method. In the hole clay mud goes by hollow drill rod. Due to hydrostatic pressure exerted by this solution with density 1.2 ... 1.3 g/cm3, pile is done without casing. Clay solution is prepared on site mainly from bentonite clays and during drilling it is injected in to the drilled hole. Then reinforcing cage is installed in the hole. Concrete mix is fed by vibrohopper into the well. Vibrating concrete mix comes into the well and displaces clay mud. (Bored piles. http://woodom.info/services/fundament/burenie-svay/info/tehnologii-burenia/)

The device of bored piles with fixing walls by casing is possible in any geological and hydrogeological conditions. Casings can be left in the soil or removed from the wells during pile production (inventory pipes). Sections of casing are usually connected by joints of special structure or by welding. Wells are drilled with special facilities by rotary or stroke method.
After cleaning the bottom and setting into a well reinforcing cage the hole is concreted by vertically movable tube (VMT). As the hole is filled with the concrete mixture, the inventory casing is being removed. (Bored piles. http://woodom.info/services/fundament/burenie-svay/info/tehnologii-burenia/)

3.5 The advantages and disadvantages of bored piles

The advantages of bored piles are:

- reduction of the excavation volume and concrete work volume
- reduction of the machinery and transport needs
- reducing the influence of a winter period at the speed and quality of a work
- ability to use for the base strong soils, which lie at a great depth
- ability to transfer to a pile loads of wider range
- possibility to make piles with larger diameter (compared to driven piles), it improves piles work on horizontal load
- economy of metal
- on building sites, which are situated in conditions of dense building, it would be a better solution to use such piles (http://stroy-machines.ru/content/view/619/87/)

The disadvantages of bored piles are:

- increased use of manual labor and the technological complexity of piles setup, especially in unstable soils
- increase of concrete consumption (compared to driven piles), because of lack of soil compaction around the pile in the process of its setup
- complexity of pile manufacture control
- large scatter of the bearing capacity values (up to 20-30%) of piles with identical size in identical soil conditions. (http://stroy-machines.ru/content/view/619/87/)

5 CONCLUSIONS

There was geology of a specific region of Russia introduced in the thesis report. A summary table with all studied sediments and soils, which form these sediments and soil characteristics was made.

Also comparative an analisis of the table soil characteristics (archive data) with soil characteristics after geology investigations on two building sites in Saint-Petersburg was done. The archive data of soils, which were on the building objects, was confirmed. After comparative analysis of the archival data with investigation data of the first building site, the soil characterictics of Quaternary sediments, which were represented by Upper Quaternary sediments of Ostashkov horizon - lake-glacial (lg Q III lz) sediments and glacial sediments of Luga stage (g Q III lz), mid-Quaternary sediments of Moscow horizon - glacial (g Q II ms) sediments and sediments of Kotlin horizon were approximately the same. And after comparative analysis of the archival data with investigation data of the second building site, the soil characteristics of marine and lake sediments (m, l Q IV) and Upper lake-glacial sediments (lg Q III) of Baltic Ice Lake were approximately the same.

It would be better to make a more full comparative analysis of all archive data using materials after geology investigations of more building sites from different localities, not only from St.-Petersburg. But now it was impossible, because of lack of such materials. Also it would be interesting to make such a work with other regions of Russia.

In the thesis report, the type of foundation used for the building in the considered geological region with its installation technology and an analysis of its advantages and disadvantages was written. Bored pile foundation is commonly used for localities with the same geological conditions as in the described region. Piles is the most appropriate type of foundation for oversaturated and weak soils. And bored piles is the most common type of foundation for building sites in conditions of dense building. But this type of foundation also has disadvantages. The main disadvantage is the large scatter of the bearing capacity values (up to 20-30%) of bored piles with identical size in identical soil conditions. It does not allow with necessary accuracy to determine the design load in the design phase and complicates the bearing capacity prediction of a pile foundation

The information of the thesis report can be useful for civil engineers and foundation designs for preliminary determination of the soil conditions in different localities of the studied region, determination of foundation installation methods, determination of a foundation type using data of soil characteristics from the summary archive table, determination of approximate foundation cost.

FIGURES

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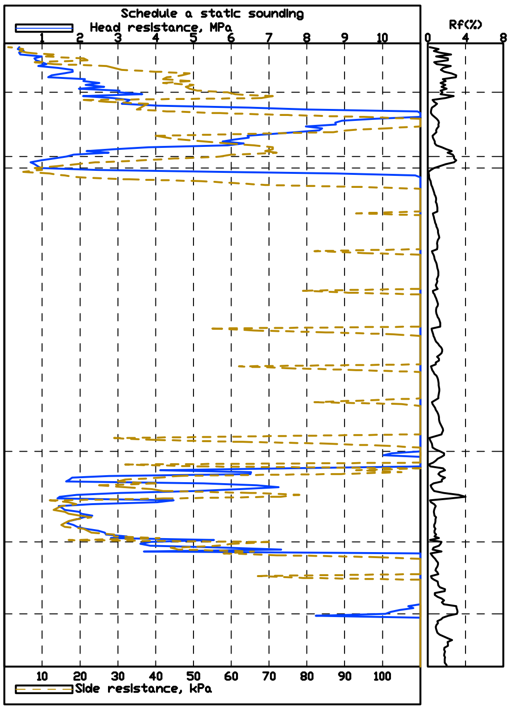
Cross-section of the hole №5333

Hole: 5333
The altitude of the mouth: 4.6m.

Geol. age.	Depth of bot.	Abs. Mark.	Thick. of layer	Lithology section	Description of soils	water app.	Set water
t IV	1.3	3.3	1.3	1	Bulk soils: sands with fragments of brick		
t IV	3.0	1.6	1.7	1.1	Alluvial soils: silty wet gray sands from depth of 2.8 m. saturated with water	2.8	2.8
b IV	3.3	1.3	0.3	2	Poorly peated brown soils saturated with water		
lg III lz	10.8	-6.2	7.5	3	Silty grayish-brown sands, with layers of dense sandy loam saturated with water		
g III lz	13.2	-8.6	2.4	4	Sandy loams brownish-gray with gravel, pebbles, plastic (prop. softplastic)		
g III lz	15.1	-10.5	1.9	5	Silty sandy loams brownish-gray with gravel, pebbles, plastic (prop. hardplastic)		
g II ms	20.8	-16.2	5.7	6	Sandy loams brownish-gray with gravel, pebbles, hard (prop. semi-solid)		
g II ms	21.5	-16.9	0.7	7	Silty sandy loams brown with gravel, pebbles, boulders, hard (prop. semi-solid)		
g II ms	24.5	-19.9	3.0	8	Light Silty loams grayish-brown with gravel, pebbles, boulders, hard (prop. semi-solid)		
V kt2	31.5	-26.9	7.0	9	Silty clays bluish-gray with fragments of dislocated sandstone,solid		
V kt2	35.0	-30.4	3.5	10	Silty clays gray-blue, solid		

Scale 1:100

TSZ: 5333
The altitude of the mouth: 4.6m.



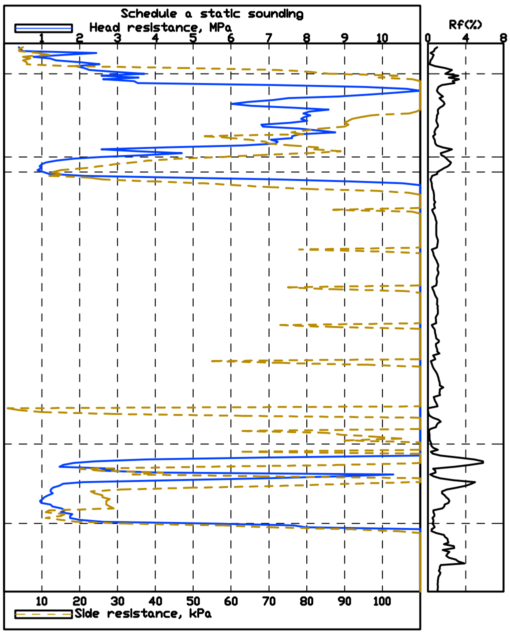
Cross-section of the hole №5335

Hole: 5335
The altitude of the mouth: 4.5m.

Geol. age.	Depth of bot.	Abs. Mark.	Thick. of layer	Lithology section	Description of soils	water app.	Set water
t IV	0.8	3.7	0.8	1	Bulk soils: sands with fragments of brick		
	3.0	1.5	2.2	1.1	Alluvial soils: silty wet gray sands from depth of 3.4 m. saturated with water		3.0
b IV	3.4	1.1	0.4	2	Poorly peated brown soils; from a depth of 3.0m. saturated with water	3.4	
lg III lz	10.6	-6.1	7.2	3	Silty grayish-brown sands, with layers of dense sandy loam saturated with water		
g III lz	12.7	-8.2	2.1	4	Sandy loams brownish-gray with gravel, pebbles, plastic (prop. softplastic)		
	15.3	-10.8	2.6	5	Silty sandy loams brownish-gray with gravel, pebbles, plastic (prop. hardplastic)		
g II ms	20.5	-16.0	5.2	6	Sandy loams brownish-gray with gravel, pebbles, hard (prop. semi-solid)		
	21.5	-17.0	1.0	7	Silty sandy loams brown with gravel, pebbles, boulders, hard (prop. semi-solid)		
	24.8	-20.3	3.3	8	Light Silty loams grayish-brown with gravel, pebbles, boulders, hard (prop. semi-solid)		
V kt2	31.5	-27.0	6.7	9	Silty clays bluish-gray with fragments of dislocated sandstone,solid		
	35.0	-30.5	3.5	10	Silty clays gray-blue, solid		

Scale 1:100

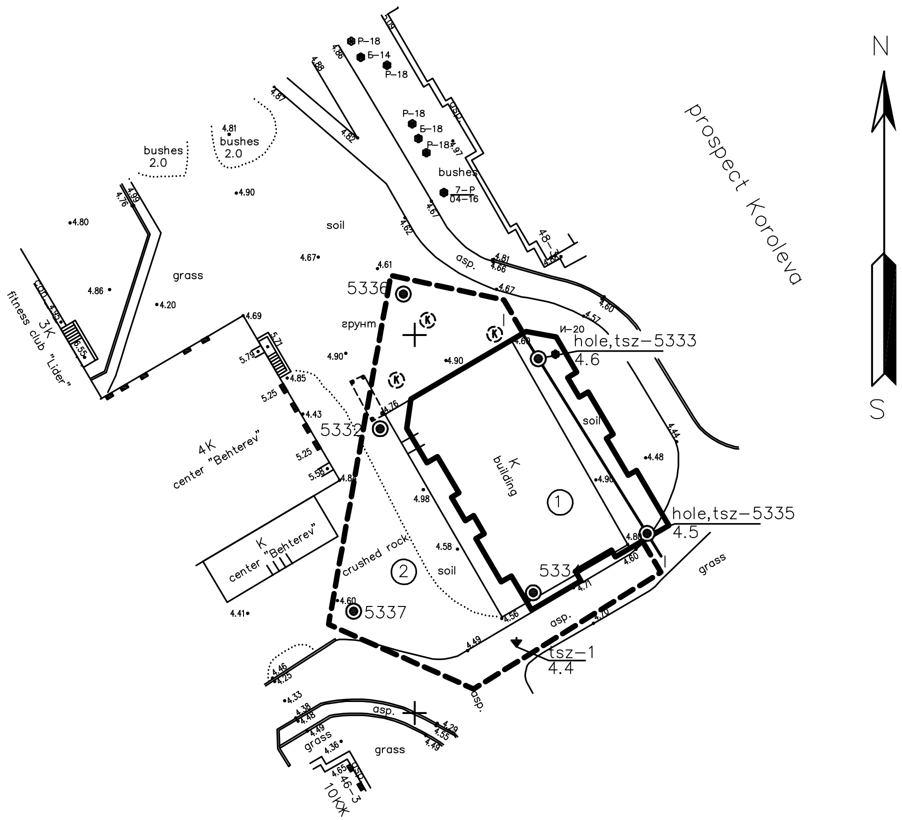
TSZ: 5335
The altitude of the mouth: 4.5m.



APPENDIX 3
1 (2)

General plan of geological holes

Scale: 1:500



Explication of buildings and structures			
according general plan	Name	Q–ty of storeys	NB.
1	Resident building	25+1tech.st.	
2	Underground parking	1	

Note:

hole,tsz–5333 / 4.6 – holes and tsz have been drilled

5332– projected holes and tsz

Table with soil characteristics

APPENDIX 4

Type of investigation	Region	Stage	Genesis		Type of soil	Saturation unit weight γ, g/sm^3	Dry unit weight γd, g/sm^3	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	2	3	4		5	6	7	8	9	10	11	12	13	14	15	16
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Glacial sediments of Karelian age		Moraine sand	2±0,14	2,2±0,14					0,34±0,09	9,52±2,8	37		20-30
					Moraine sandy loam	2,01±0,09	2,2±0,08	12±1,7		5±1,3		0,32±0,06	11±3			20-30
					Moraine loam	1,93± 0,1	2,18±0,07	15±2,5		10±2,7		0,40±0,07	15±3,6	25-29	15-82	20-30
			Fluvioglacial sediments of Karelian age		Moraine sand									57-64		24-48
					Moraine sandy loam											22-35
			The sediments of local and regional proglacial lakes	Sediments proglacial lakes	Sand	1,86±0,2	1,58±0,11					0,70±0,12	18±7,2	33±6		26
					Sandy loam	2,06±0,1	1,69±0,11	18±2,5		5±1,3		0,61±0,11	2,2±4,3	32	17	11
					Loam of medium density	2,02±0,1	1,60±0,07	19±2,6		10±2,5		0,69±0,07	27±5,9	21±8	30±15	7±3,6
					Weakly compacted loam	1,89±0,1	1,41±0,07	20±2,9		12±2,3		0,92±0,13	34±6,2	16±8	22±13	3,5±1,9
					Weakly compacted clay	1,88±0,1	1,4±0,07	26±6		20±5,4		0,93±0,1	42±16	12±5	22±14	4±2,1
				Sediments internal glacial lakes	Sand	1,76±0,2	1,55±0,06					0,72±0,12	13±8,1			26
					Sandy loam	2,03±0,1	1,69±0,13	17±3,1		6±1,1		0,61±0,13	21±4			9
					Loam	2,03±0,2	1,64±0,13	17±1,8		10±2,7		0,66±0,15	24±4,8			9

Type of investigation	Region	Stage	Genesis	Type of soil	Saturation unit weight γ, g/sm³	Dry unit weight γd, g/sm³	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Marine late glacial sediments	Clay	1,83±0,12	1,34±0,16	42±9,7		19±6,3		1,1±0,29	44±15,3	11-13	10-26	4-10,5
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Marine late glacial sediments	Sand	2,01	1,65					0,6	22			
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene sea sediments	Clay	1,66±0,11	1,05±0,18	55±8,7		27±5,9		1,67±0,43	62±16,1	2-19	2-50	0,5-1,8
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene sea sediments	Loam	1,91±0,11	1,43±0,17	34±6,6		12±2,8		0,90±0,27	35±11,1			
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene sea sediments	Sand	1,73	1,63					0,63	6			
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene lake sediments	Sand	1,82±0,19	1,58±0,12					0,7±0,1	17±9,7	34-38		33-54
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene lake sediments	Sandy loam	1,89±0,13	1,48±0,28	17±3,6		6±1,6		0,83±0,09	28±8,8			
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene lake sediments	Loam	1,91±0,15	1,54±0,22	20±3,6		10±3,8		0,79±0,22	25±6,7			
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Holocene lake sediments	Clay	1,63±0,16	1,07±0,25	31±9		19±7,2		1,74±0,39	64±18	10	8	0,4-2,3
Archive data	**Baltic shield**	***Pleistocene-Holocene***	Peat-bog formations of the Holocene	Peat	0,95-1,05						11-26	570-1700			
Archive data	**Baltic region**	***Upper Proterozoic***	Vendian complex (Kotlin horizon)	Clay	2,14		22		10	-0,46	0,49	17	27	97	25-30
Archive data	**Baltic region**	***Upper Proterozoic- Lower Cambrian***	Terrigenous marine formation	Laminaritovye clay	2,16±0,07	1,9±0,08	22,7		14±3,7		0,45±0,06	13,6±2,6	15-22	47-73	675±391
Archive data	**Baltic region**	***Upper Proterozoic- Lower Cambrian***	Terrigenous marine formation	Blue clay	2,26	1,99	26		17		0,39	14	15-22	47-73	28±8
Archive data	**Baltic region**	***Ordovician-Silurian***		Limestone	2,26-2,45						4,3-20,2				33-91* 27-75**
Archive data	**Baltic region**	***Ordovician-Silurian***		Dolomite	2,21-2,68						11,3-19,9				37-143* 19-119**
Archive data	**Baltic region**	**Devon**	Formation of red terrigenous Early Devonian	Clay	2,08±0,4	1,62±0,07	29±3,4		24±3,2		0,68-0,06	25±3,2	13	97	20-70

Type of investigat	Region	Stage	Genesis			Type of soil	Saturation unit weight γ, g/sm^3	Dry unit weight γd, g/sm^3	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	2	3	4			5	6	7	8	9	10	11	12	13	14	15	16
Archive data	Baltic region	Pleistocene-Holocene	Glacial sediments		Dnepr moraine	Loam	2,25±0,08		10,6±4		9,2±2,1		0,33±0,4	10,7±2,5			10-15
						Sandy loam	2,14±0,09	1,96±0,09	11±0,5		6±0,8		0,38±0,06	8,9±1,3	33	53±14	15-25
					Moscow moraine	Loam	2,22±0,08	1,94±0,15	15±3,4		7±3		0,41±0,11	15±5,9	27±5	28±8	10-15
						Sandy loam	2,23±0,07		10,5±3		5,8±0,8		0,33±0,04	10,6±8,2	30±4,5	34±11	6-9
					Kalinin moraine	Loam	2,14±0,07	1,85±0,11	12,7±1		9,4±2,2		0,45±0,07	14,7±2,5	23±2,5	31±10	10-15
						Sandy loam	2,22±0,09	1,98±0,1	12,1		5,4±1		0,36±0,07	11,2±2	30±4,2	35±10	15-25
					Ostashkov moraine	Loam	2,08±0,08	1,73±0,13	18±3		11±3,3		0,59±0,12	22±4,7	24-28	20-70	10-15
						Sandy loam	2,2±0,08	1,93±0,13	14±2,9		4±1,6		0,4±0,1	15±4	27-33	15-60	15-25
						Sand									33-37		17-35
			Fluvioglacial, between moraine and after glacial sediments	Water glacial sediments	Late moskow horizon	Silty sand	1,88±0,15	1,75±0,09					0,51±0,08	9,6	32-38		14-88
						Fine sand	1,81±0,1	1,69±0,08					0,57±0,08	6,5	32-38		14-88
						Average coarse sand	1,81±0,09	1,69±0,07					0,57±0,07	5,9	32-38		14-88
					Late ostashov horizon	Silty sand	1,74±0,1	1,54±0,08					0,74±0,05	13±3,5	32-38		21-37
						Average coarse sand	1,69±0,4						0,66±0,04				16
						gravel sand	1,92±0,07						0,45±0,05				50-60
			The sediments of local and regional glacial lakes of Late glacial age	Interstadial sediments		Sandy loam	2,19±0,17	1,73±0,14	19±3,2		4±2		0,58±0,13	21±5,3	33±6	14±11	10-22
						Loam	1,98±0,13	1,59±0,20	22±7,4		11±6		0,76±0,33	27±12	24±7	20±17	7-10
						Silty fine sand	1,88±0,23	1,66±0,14					0,65	18±8			10-22,5
				The sediments of local glacial lakes		Clay	1,91±0,06	1,46±0,1	27±3,2		22±3		0,88±0,12	31±4	10-11	20-30	6-11
						Loam	1,93±0,06	1,56±0,06	23±2,4		14±2		0,76±0,08	27±3			5-10
				The sediments of regional glacial lakes		Sandy loam	2,02±0,08	1,65±0,13	18±4		5±2		0,65±0,13	23±6	33±6	14±11	10-22,5
						Loam	1,89±0,08	1,43±0,13	22±3		15±5		0,95±0,19	34±7	24±7	20±17	5-10

Type of investigati	Region	Stage	Genesis		Type of soil	Saturation unit weight γ, g/sm^3	Dry unit weight γd, g/sm^3	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	2	3	4		5	6	7	8	9	10	11	12	13	14	15	16
Archive data	Baltic region	Pleistocene-Holocene	The sediments of local and regional glacial lakes of Late glacial age	The sediments of regional glacial lakes	Bandy clay	1,77		24		28		1,28	50	10-11	20-30	5-10
			Sea post-glacial sediments	I Yoldia Sea	Sandy loam	2,04±0,15	1,71±0,15	19±2,1		3±2		0,6±0,13	22±4	32±7	23	12,1±7,7
					Loam	1,93±0,1	1,49±0,16	21±3,3		14±5,7		0,87±0,22	32±7			5-10
				II Yoldia Sea	Loam	1,95±0,11	1,53±0,12	18±2,7		9±2,7		0,81±0,14	26±7			4-6
				Ancylus Sea	Sandy loam	1,99±0,34	1,54±0,17	21±2,2		4±2,4		0,63±0,1	31±7			5-9
					Loam	1,42±0,1	1,16±0,3	21±5,1		10±4		0,85±0,19	31±7			4-8
				Litorinal Sea	Sandy loam	1,88±0,16	1,47±0,24	23±5,7		6±3,6		0,9±0,38	47±2	28±6	19±11	4,8±3,4
					Loam	1,83±0,2	1,35±0,29	23±4,7		12±6,3		1,05±0,54	42±21	27±4	9±7	5±2,5
					Silty fine sand	1,97±0,1	1,58±0,1					0,65±0,12	26±5			9
			Alluvial Upper Pleistocene and Holocene sediments		Silty sand									30-40		14-67
					Fine sand									30-40		27-71
					Average coarse sand									30-40		33-51
					Gravel sand									30-40		31-173
					Sandy loam									15-20	17-20	4-8
					Loam									3-5	15-25	5-11
					Clay									15-20	25-47	3-10
		Holocene (recent sediments)	Technogenic sediments t Q IV	Top soils	Silty sand with fragments of bricks	R_0≈100 kPa										
				Alluvial soils	Gray silty wet sand	1,86						0,75		26	3	10

Type of investigatio	Region	Stage		Genesis	Type of soil	Saturation unit weight γ, g/sm^3	Dry unit weight γd, g/sm^3	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16
Investigation data (St.-Petersburg, Koroleva 46) N1	Baltic region	Pleistocene-Holocene	Holocene	Biogenic sediments b Q IV	Slightlypeated brown soils saturated with water	1,55	0,92					1,719	68,6			
			Upper-Quaternary sediments of Ostashkov horizon	Lake glacial Luga sediments lg Q III lz	Silty grayish-brown sands,with layers of dense sandy loam saturated with water									34-39	2-6	28-45
				Glacial sediments of Luga stage g Q III lz	Sandy loams brownish-gray with gravel, pebbles	2,28	2,04	10,6	13,1	2,5	0,39	0,311	11,5	26	30	13
					Silty sandy loams brownish-gray with gravel, pebbles	2,27	2,045	10,8	13,4	2,6	0,1	0,307	11	26	30	13
			Middle-Quaternary sediments	Glacial sediments of Moscow horizon g Q II ms	Sandy loams brownish-gray with gravel, pebbles, hard (prop.semi-solid)	2,33	2,15	11,6	14,8	3,2	-0,96	0,248	8,5	32	35	22
					Silty sandy loams brown with gravel, pebbles, boulders, hard (prop. semi-solid)	2,17	1,87	17	24	7	-0,13	0,448	16,1	32	35	22
					Light Silty loams grayish-brown with gravel, pebbles, boulders, hard (prop.semi-solid)	2.09	1,72	21,4	31,8	10,4	-0,03	0,581	21,2	32	35	22

Type of investigatio	Region	Stage		Genesis	Type of soil	Saturation unit weight γ, g/sm³	Dry unit weight γd, g/sm³	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16
Investigation data N1	Baltic region	Upper Proterozoic	Vendian complex	Kotlin horizon V kt_2	Silty clays bluish-gray with fragments of dislocated sandstone,solid	2,12	1,80	23,2	34,8	11,6	-0,47	0,515	17,7	≈27	≈97	≈20
					Silty clays gray-blue, solid	2,14	1,85	21,1	31,2	10,1	-0,56	0,469	15,5	≈27	≈97	≈20
Investigation data (Dacha Dolgorukova) N2	Baltic region	Pleistocene-Holocene	Holocene (recent sediments)	Technogenic sediments t Q IV	Fine granite crushed stone, top soil											
					Wet gravel sand with average density											
					Light-brown fine sand of middle density, wet											
					Dark-gray fine sand of average density with gravel, pebbles and waste											
				Biogenic sediments b Q IV	Black color peat with water, dense											
				Sea and lake sediments m,l IV	Peated loam with thin layers of silty sand, sandy loam	1,94	1,41	24	29	5	2,8	0,91	38	9	3	4
					Gray rarely peated loam	1,86	1,5	21	26	5	0,6	0,8	24	21	22	10

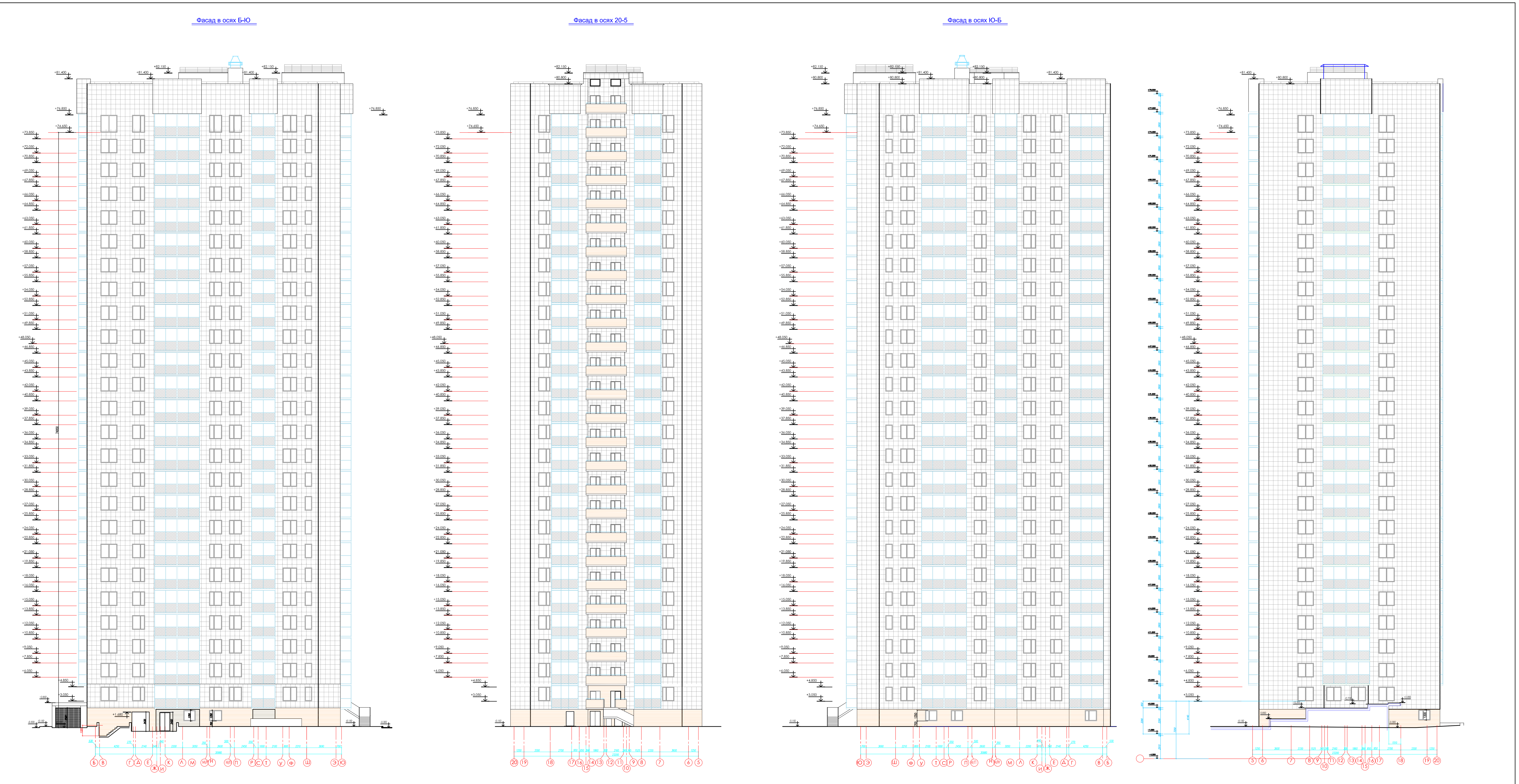
Type of investigation	Region	Stage		Genesis	Type of soil	Saturation unit weight γ, g/sm³	Dry unit weight γd, g/sm³	Plastic limit Wp, %	Liquid limit WL,%	Plasticity Index Ip, %	Liquidity Index IL	Coefficient of soil porosity e	Natural moisture content W, %	Angle of internal friction, φ°	Cohesion c, kPa	Modulus of deformation E, MPa
1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16
Investigation data N2	**Baltic region**	**Pleistocene-Holocene**	Upper-Quaternary sediments	Lake glacial sediments lg Q III	Silty heavy loam of gray color with thin layers of sandy loam and silty sand, saturated with water	1,75	1,17	31	45	14	1,29	1,33	49	6	8	4
					Silty light loam of gray color with thin layers of sandy loam and silty sand, saturated with water	1,84	1,36	23	32	9	1,33	0,99	35	12	9	6
					Silty light loam of gray color with thin layers of sandy loam and silty sand, saturated with water	1,98	1,6	20	29	10	0,4	0,69	24	21	27	11

compression strength

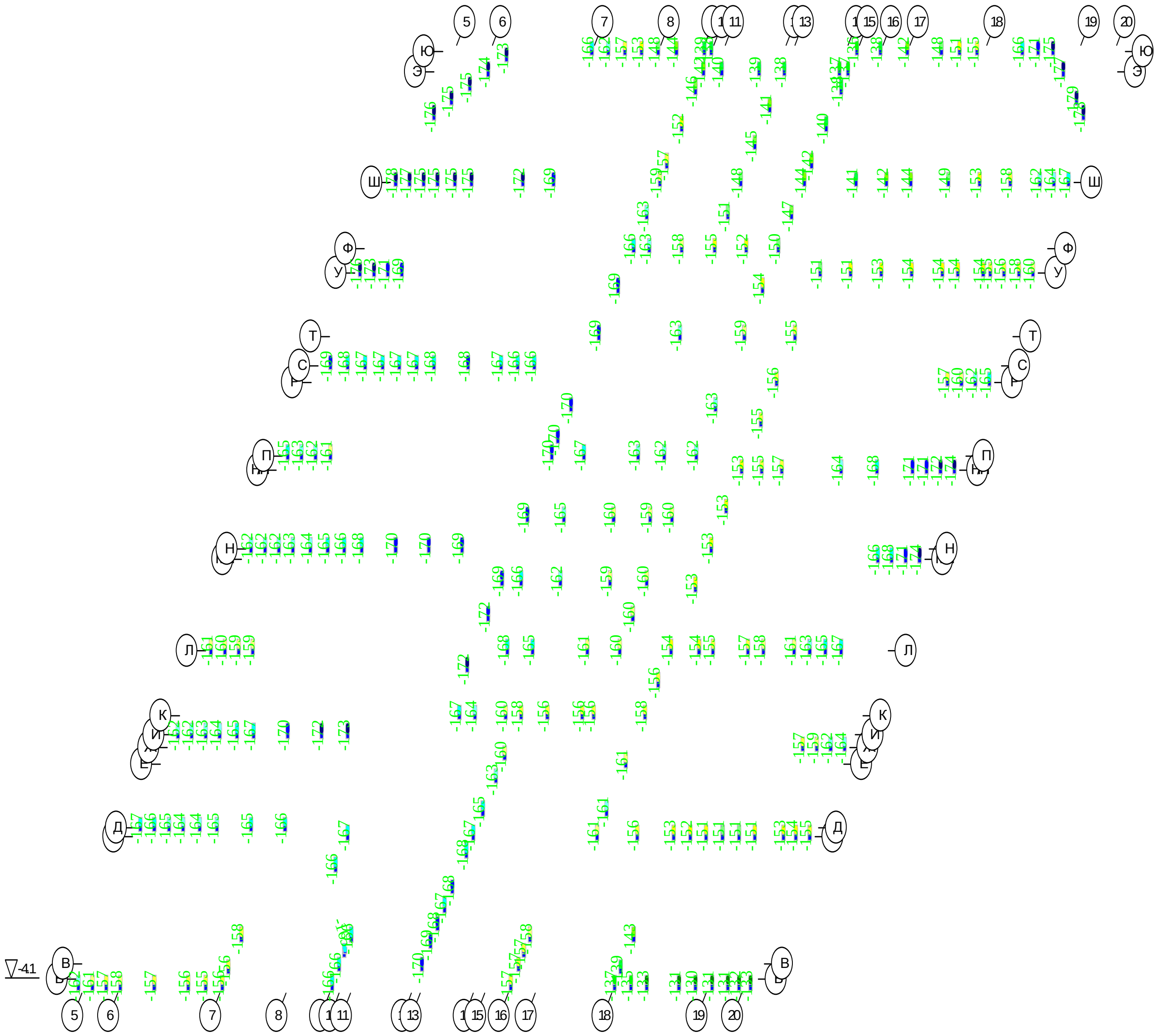
*air dry

** water saturated

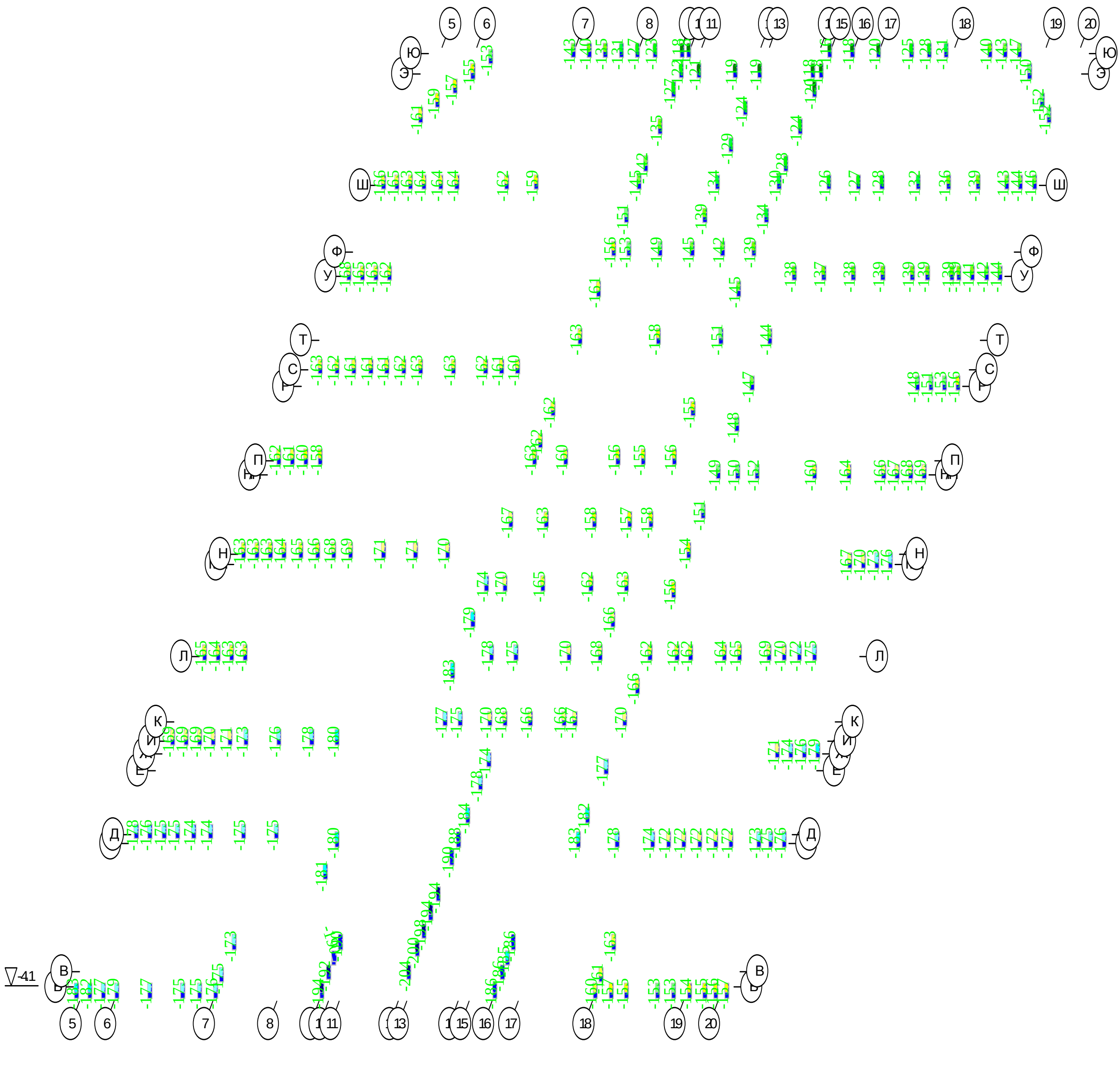
Facades of the building.



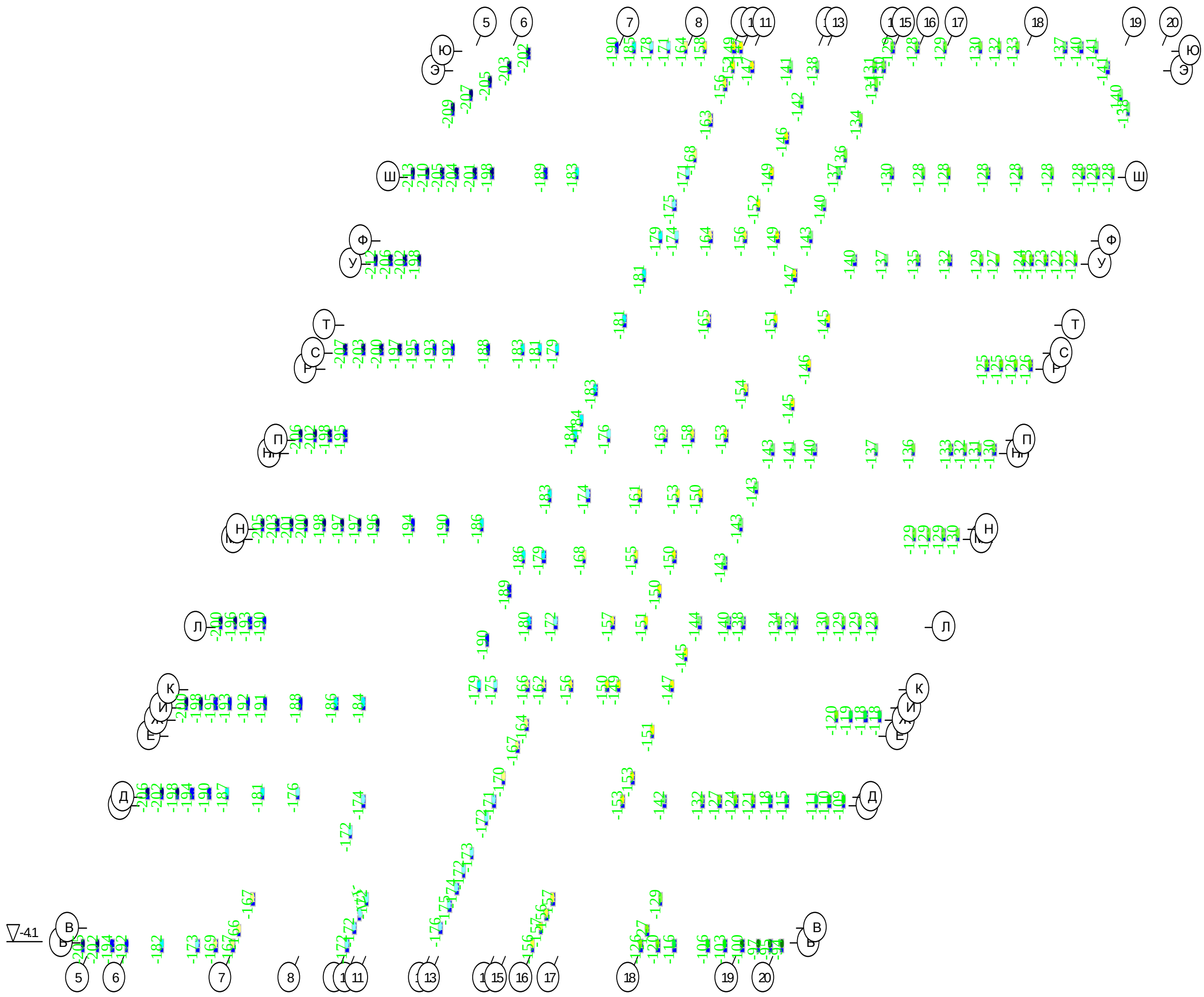
Efforts on piles. Combination 1. (t*f)



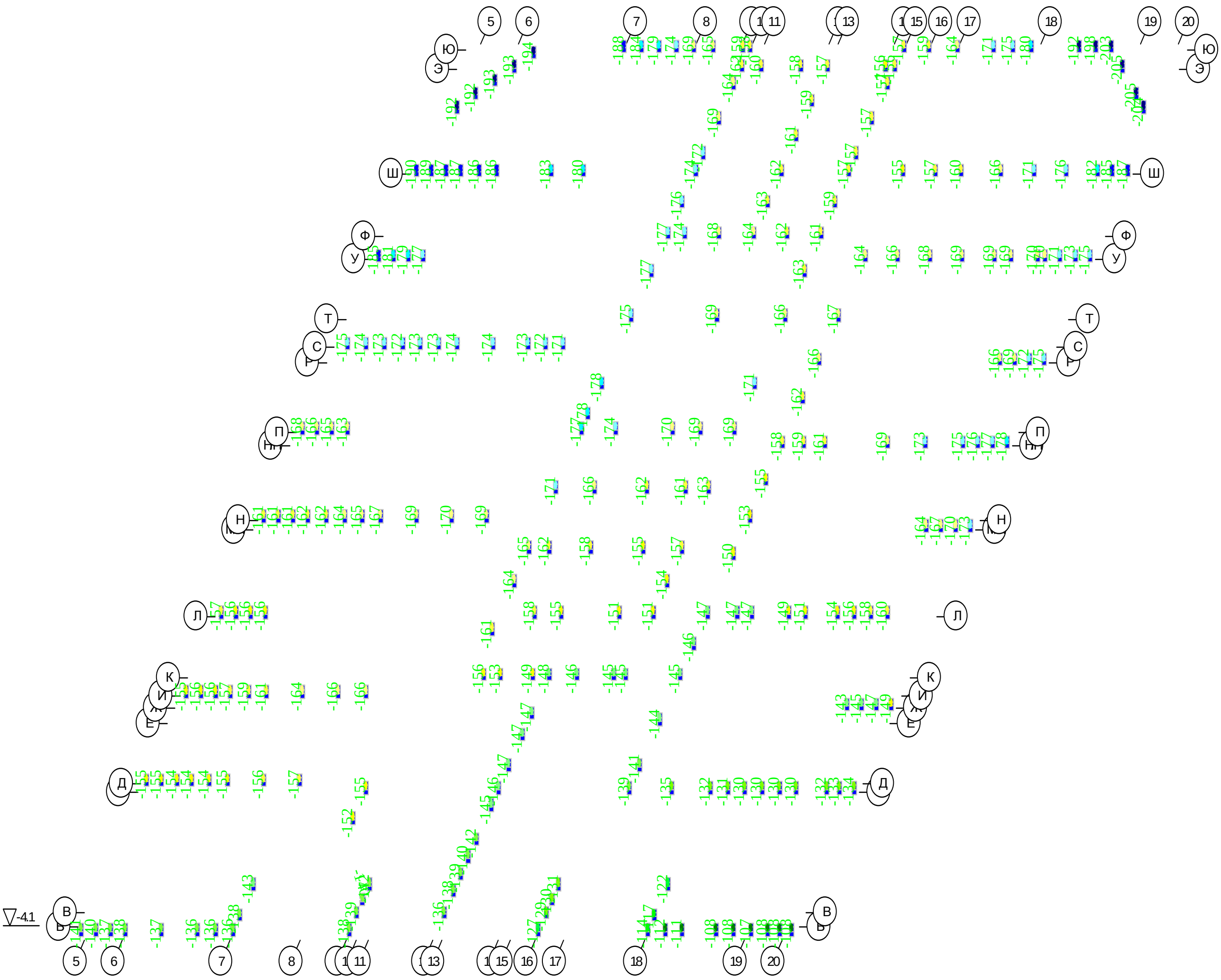
Efforts on piles. Combination 2. (t*f)



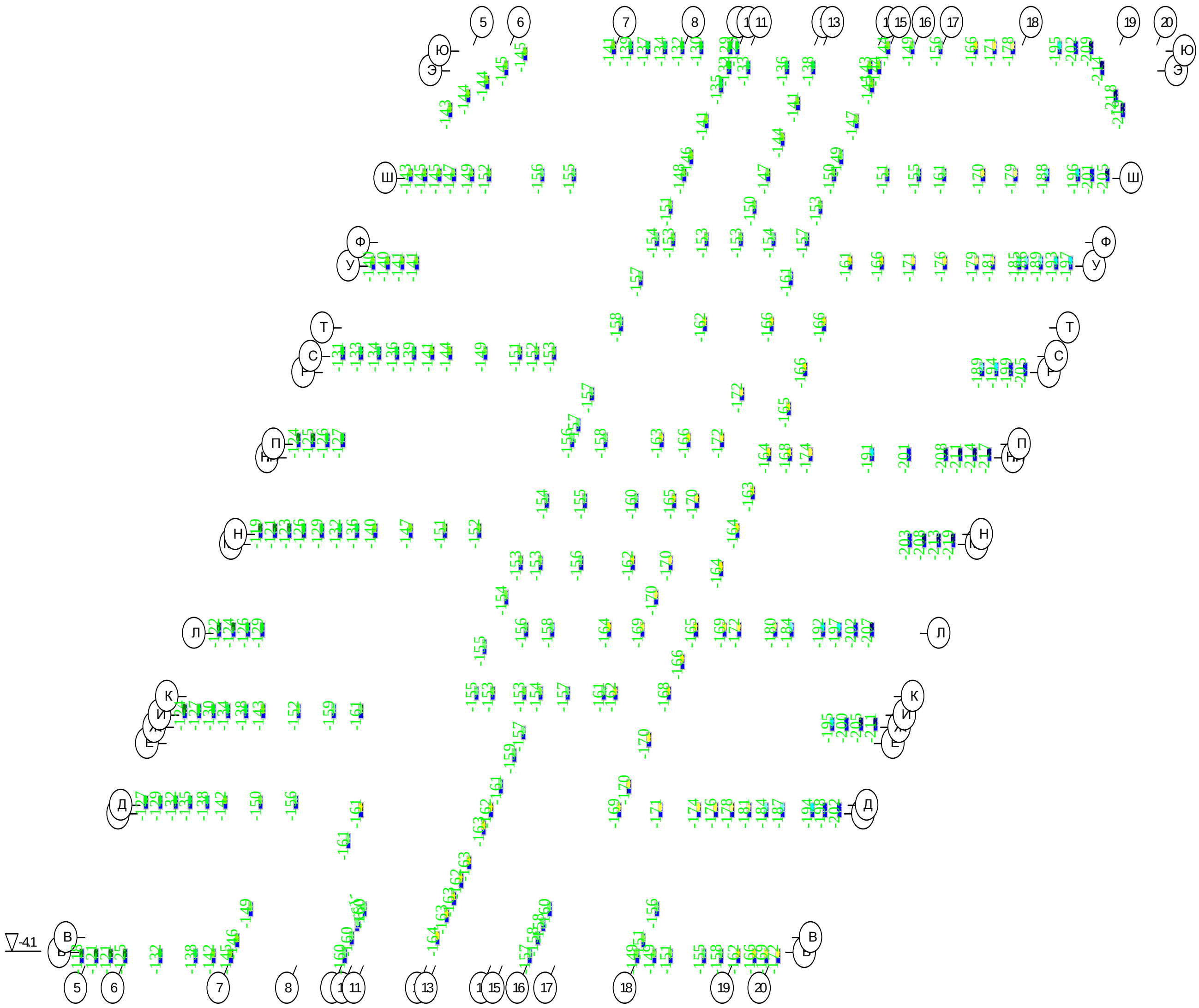
Efforts on piles. Combination 3. (t*f)



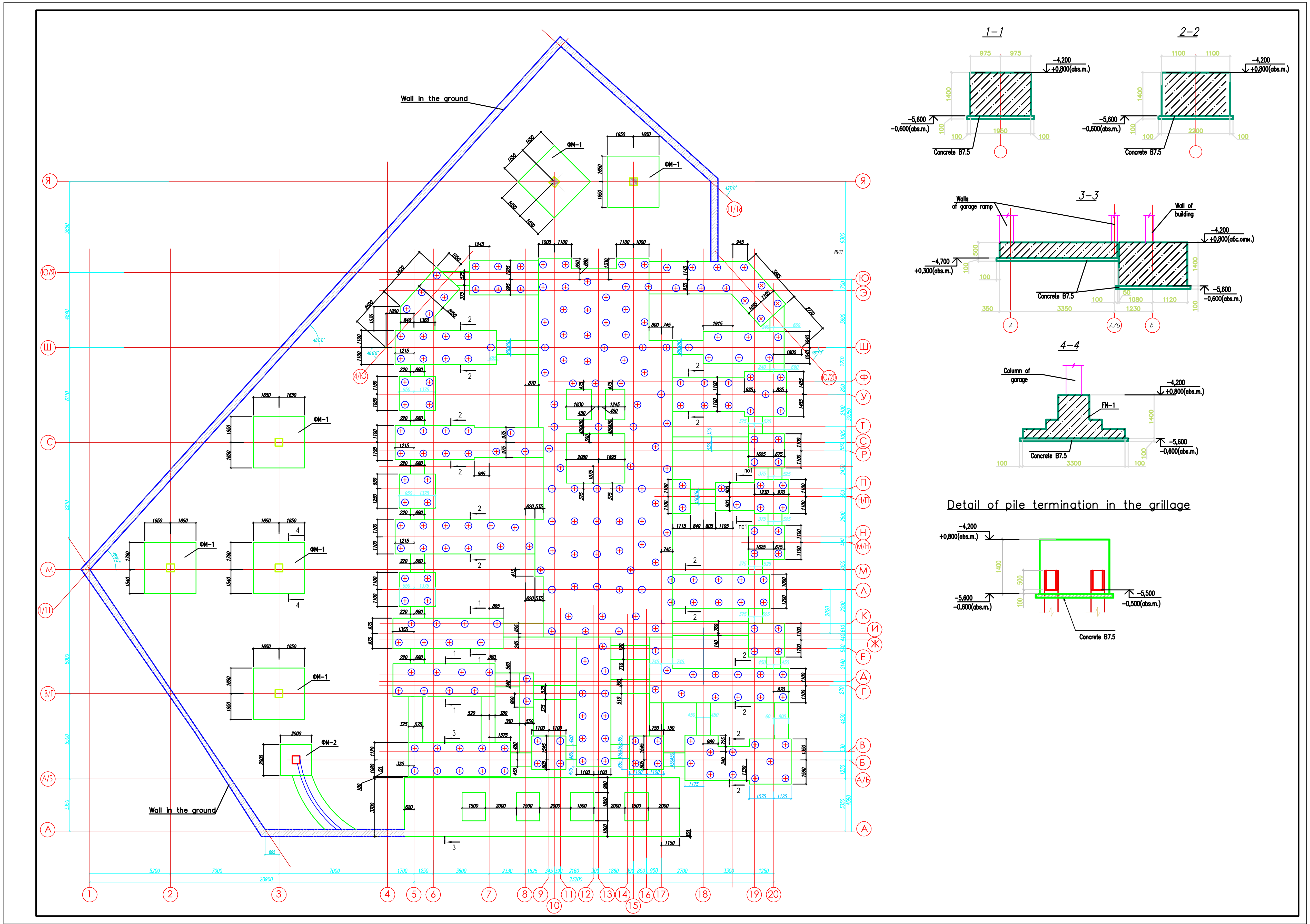
Efforts on piles. Combination 4. (t*f)



Efforts on piles. Combination 5. (t*f)

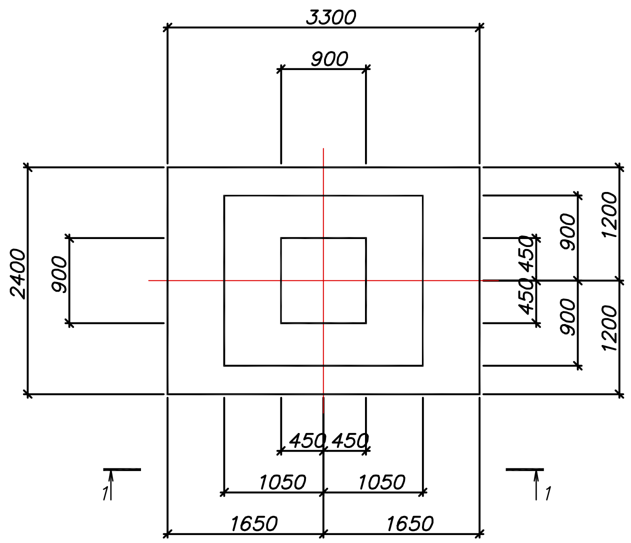


Plan with situation and dimensions of pile foundations, wall in the ground, foundation on natural soil.

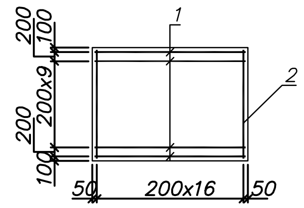


Foundation on natural basis with its dimensions.

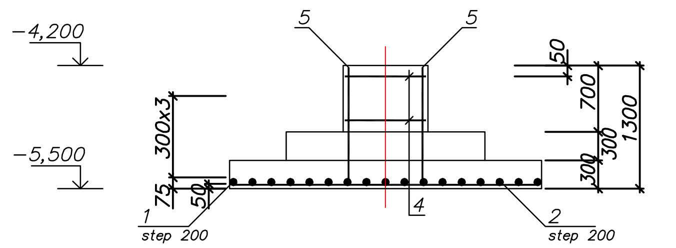
FN1



The scheme of layout reinforcement at the bottom



1 — 1



Спецификация фундамента Фм1

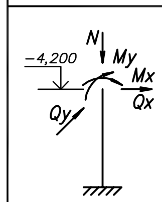
Поз.	Обозначение	Наименование	Кол.	Примеч.
		Детали		
		СТО АСЧМ 7–93		
1		ø16А400С L=3250	12	5.13 кг
2		ø12А400С L=2350	17	2.09 кг
3		ø12А400С L=1250	10	1.11 кг
4		ø10А400С L=850	8	0.52 кг
5		ø12А400С L=1250	10	1.11 кг
6		ø10А400С L=850	8	0.52 кг
		ГОСТ 5781–82*		
7		ø6 А–I L=708	12	0.16 кг
		Материалы		
		Бетон класса В20		4.08 м3

Ведомость расхода стали, кг

Марка элемента	Изделия арматурные								Всего
	Арматура класса								
	А–I			А400С					
	ГОСТ 5781–82*			СТО АСЧМ 7–93					
	ø6		Итого	ø10	ø12	ø16		Итого	
Фм1	1.9		1.9	8.4	57.7	61.6		127.6	129.5

по адресу : г.Санкт–Петербург, Приморский район, пр.Королева, дом 46, корп.4
основанием столбчатых фундаментов служат пески пылеватые плотные насыщ. водой, плотностью – 2,07т.м3, угол внутреннего трения 34°, сцепление 0.06кгс/см2, коэффициент пористости – 0,550, модуль деформации 280кгс/см2

Loads on foundation

Scheme of loads	N comb	Calculation of strength					Calculation of the deformations				
		Mx тсм	Qx тс	My тсм	Qy тс	N тс	Mx тсм	Qx тс	My тсм	Qy тс	N тс
	1	11.0	0.0	2.0	0.0	185.0	9.2	0.0	1.7	0.0	154.2
	2	2.0	0.0	6.0	0.0	185.0	1.7	0.0	5.0	0.0	154.2
	3	4.0	0.0	7.0	0.0	185.0	3.3	0.0	5.8	0.0	154.2