Properties of Rocky Rocks in Primorsky Regional Deposits Used to Construct the Infrastructures

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Abstract. The article contains the analysis and generalization of DalNiis research results regarding the properties of rocky rocks in Primorsky Regional deposits (gabbrides, granodiorites, basalts, porphyrites, limestones) which are most widely used to construct the infrastructural objects: Zvezda Shipyard, Vostochny-Nakhodka Transport Hub, Sea Coal Complex in Sukhodol Bay, Vladivostok – Vostochny Port Highway.

The article presents the main physical & mechanical characteristics of building rock stone for Maly Iosif deposit - Yuzhny section, fields of Smolyaninovo-2, Kuznetsovskoe, Vasilievskoe-2, Vrangelevskoe, Golubinaya Gora, Otkrytoe, Pribrezhnoe, Ferma-1.

1. Introduction

The development of transport infrastructure and the creation of new production facilities for the shipbuilding industry in Primorsky Region is resulted to provide the facilities under construction with such inert materials as building stone, rubble, sand, sand-gravel mixture.

So, for example, the hundreds of thousands of cubes of local building rocky stone and rubble are required only for such objects as Zvezda Shipyard, Vostochny-Nakhodka Transport Hub, Sea Coal Complex in Sukhodol Bay, Vladivostok – Vostochny Port Highway.

Igneous, metamorphic and sedimentary hard rocks having at least 30 MPa compressive strength are used to construct the various structures in the road, industrial & civil and marine hydraulic engineering.

Suitability of the rocky rocks for hydraulic engineering (berthing, protective, shore protection and other facilities) is controlled by departmental building regulations BCH 5-84 "Use of natural stone in marine hydraulic engineering". In accordance with this standard the main physical & mechanical characteristics for rocky rocks are a compressive strength in the dry and water-saturated condition, softening coefficient, frost resistance, water absorption, rock density, presence of weathered rocks and clay-sand impurities as well as content of sulfur and sulfate compounds in SO₃ terms.

Suitability of the rocky rocks to be used as a filler for heavy concrete as well as in road and other construction works is regulated by standard GOST 31436 “Rocky Rocks to produce the rubble for construction works”. In accordance with this standard it is necessary to investigate additional characteristics as follows: the content of weak rock grains and crushed grains, the grade of crushability and abradability and the presence of harmful components and impurities.

The article contains the analysis and generalization of DalNIIS research results regarding the properties of rocky rocks in Primorsky Regional deposits (gabbrides, granodiorites, basalts, porphyrites,
limestones, andesites) which have been most widely used to construct the infrastructural objects in the past two years.

At the present time the rocky rocks of the following deposits: Yuzhnoe, Smolyaninivo-2, Kuznetsovskoe, Vasilievskoe-2, Vrangelevskoe, Golubinaya Gora, Otkryt, Pribrzhnoe, Ferma-1 are actively used in a construction

2. Characteristics of deposits

Vrangelevskoe granodiorites. This deposit is located 1 km east of Vostochny port, Vrang Bay. Deposit and vast territory adjacent to it are a part of large plutonic massif on the east coast of Nakhodka Bay. Deposit overburden is represented by loose deluvial-eluvial sediments up to 6 m thick and weathered rocky rocks up to 30 m thick. Granodiorite minerals are distributed by number as follows: feldspars 70-75% (sodium-calcium feldspars prevail over potassium feldspars), quartz 17-20%, biotite and hornblende up to 10%, accessory and ore minerals – percent fractions.

Smolyaninivo-2 basalts. This deposit is located in Shkotovsky District, 0.5 km west of settlel. Smolyaninovo, on Shkotovka - Sukhodol river watershed, in the southern part of Skotovsky basalt plateau. The quarry rocky rock is represented by basalts. The basalt cover consists of several streams which are sometimes clearly separated from each other by residual soil. Red, brown and black grey slag is found in the upper part of such streams. In addition to basalts there are sand, clay and pebbles. Some interbedded sedimentary rocks represented by tuff-bearing sandstones with lignite streaks and tuffits are found there. Basalt texture is porous: from fine to almond-shaped porosity. The pores in basalts having a large porosity are up to 10%, the number of pores is up to 50%.

Pribrzhnoe gabbrorides. This deposit is located 7 km north of Vostochny port and 10 km south-east of Nakhodka city. The main rocks are amphibolites, gabbro and diorites which are degneissic and migmatites. The most common rocks are dark-green and dark-grey gabbro being degneissic, banded and having gneissoid texture and prismatic-granular structure. They include the andesine 40-60%, sometimes up to 80%, and hornblende. There are accessory minerals such as apatite, sometimes sphene, magnetite.

Kuznetsovskoe limestones. This deposit is located on the right bank of Partizanskaya river, 1 km southwest of the railway station Boets Kuznetsov, Primorsky Region. Besides limestone, there are sandstones, siltstones, conglomerates, gravelites, carbon shales and tuffaceous rocks. Limestone irregularity is caused by their lenticular structure. Metamorphosed gabbroid intrusions penetrated by Early Paleozoic granitoids also take part in this territory structure. Granites have been found in the southern part of this deposit.

Golubinaya Gora limestones. This deposit is located 5 km southwest of Mnogoudobnoe village, Shkotovsky District, on the right bank of Artyomovka river. The deposit is represented by two benches: lower and top. Lower bench is limestone & sandstone and composed of sandstones, tuff sandstones, conglomerates, calcareous sandstones, limestones. Top bench is sandstone and represented by fine-grained sandstones and beds of siltstones. There are fine and medium grained, crystalline limestones. Dolomite, calcite, ankerite, feldspar, sometimes quartz, rare fragments of different rocks are forming a part of this area. The productive layer thickness is 16-23 m.

Maly Iosif andesite porphyrites, Yuzhny field. This deposit is located at the southern edge of Bolshoy Kamen town, Shkotovsky District, and has a zonal structure. Its central part and roots are composed of the coarse-grained gabbro-porphyrites including the hornblende in form of sheaf-like aggregates, but its wings are composed of aphyric andesite porphyrites and dolerites. There are numerous minor dikes and sills of pyroxenites, gabbro and diorite-porphyrites.

Mined rocks here are represented by andesite porphyrites. Rock structure is porphyritic. In porphyric inclusions there are plagioclases mainly of medium composition (andesine, labrador) and hornblende. Phenocrysts are 5-10%. There are also vitric specimens, almost sub-amorphous, havinf an aphyric texture. Thickness of calcite-veined rocks is within fragments to 2 mm.
Ferma-1 andesites and diorites. This deposit is located in Shkotovsky District, on the spurs of Ferma mountain (Sukhodol and Petrovka river divide), north of settl. Tsarevka. Territory is composed of diorites, andesites, porphyrites, sandstones, siltstones, tuffites conglomerates and dyke-like massifs.

Magmatic intrusive rocks of medium composition - diorites and their effusive analogues - andesites are used as a building stone. Diorites are composed of plagioclase of medium composition (35–40%), orthoclase (15–20%), quartz (up to 5%) and hornblende, pyroxene, biotite (up to 25–35%) as a colored mineral. Porphyric intrusions are 10–15% the rock volume and represented by plagioclase and hornblende.

Otkrytoe andesites. This deposit is located in area of Otkryty Cape within Petrovsky depression of Muravyovsk-Danube zone. This massif has a zonal structure. Its central part is composed of gabbro-porphyrites and its wings are composed of aphyric andesite porphyrites and dolerites. Closer to Otkryty Cape coast there are smaller masses of minor intrusions with prevailing rock: gabbro, gabbro-diorites and effusive andesites. These rocks make up 60-70%, The rest rocks are diorites and diorite-porphyrites.

3. Research results
Studies of the physical & mechanical characteristic of rocky rocks for the above deposits of Primorsky Region are resulted in Table below.

Table 1. Physical & mechanical characteristics of rocky rocks for the above deposits of Primorsky Region.

| № item | Technical factors | Smolnianino-vo-2 (basalts) | Vasiilevskoe-2 (andesites) | Kuznetsovskoe (limestones) | Vranglevskoe (granodiorites) | Golubnaya Gora (limestones) | Otkrytoe (andesites) | Pribrezhnoe (gabbrodiorites) | Ferma-1 (andesites, porphyritic, diorites) | Yuzhnoe (andesites) |
|--------|-------------------|---------------------------|--------------------------|--------------------------|-----------------------------|----------------------------|----------------------|------------------------|-------------------------------|------------------|
| 1      | Average density (dry basis), g/sm³ | 2,4-2,62 | 2,62-2,69 | 2,62-2,65 | 2,63 | 2,58 | 2,79-3, | 2,62 | 2,64 |
| 2      | Bulk density (air dry basis), kg/m³ | 1225-1550 | 1520-1570 | 1580-1600 | 1300-1600 | 1800 | 1595 | 1960 | 1440-1530 | 1635 |
| 3      | Real density, g/sm³ | 2,7 | - | 2,7-2,71 | 2,7-2,74 | 2,73 | 2,64 | 3,06 | 2,8 | 2,71 |
| 4      | Content of dust and clay particles, % | 1-8 | 0,16-0,22 | - | 0,8-2,1 | 10,9 | - | 2,0 | 1,0 | 6,0 |
| 5      | SO³ weight content | 0,02-0,18 | - | 0,024-0,091 | 0,02-0,1 | 0,27 | 0,9 | 0,03 | 0,04 | 0,22 |
| 6 | Cl weight content | - | - | - | - | 15.88 | - | - | - |
| 7 | SiO<sub>2</sub> mmol/l | - | - | - | - | 9.42 | - | - | - |
|   | Compressive strength (dry basis), MPa | 109.5-156.6 | 292 | 54.0-224.5 | 161.6-224.5 | 112.0 | 182.3 | 329.4 | 180.5-158.4 | 217.7 |
|   | Compressive strength (water saturation basis), MPa | 48.5-121.7 | - | 37.0-184.0 | 140.1-185.9 | 95.3 | 121.6 | 312.2 | 102.9-169.2 | 203.2 |
|   | Rock strength grade | 400-1000 | 1400 | 300-1400 | 1400 | 800 | 1200 | 1000-1400 | 1400 |
|   | Softening factor | 0.37-0.94 | 0.79 | 0.69-0.99 | 0.82-0.92 | 0.85 | 0.67 | 0.95 | 0.57-0.91 | 0.93 |
|   | Frost resistance grade | F50-F400 | F50 | F200-F300 | F300-F400 | F200 | F25 | F150-F400 | F50-F300 | F150 |
|   | Water absorption, % | 0.34-3.4 | 0.51-0.88 | 0.11-0.87 | 0.20-0.39 | 0.7 | 0.14 | 0.10 | 1.07-1.4 | 0.24 |
|   | Weathering factor | 0.64 (medium weathered) | - | - | 0.8 (heavy weathered) | - | - | 0.46 (unweathered) | - | - |
|   | Crushability factor | 1000-1200 | 1400 | - | - | 1000 | - | 1400 | 1400 | 1400 |
|   | Durability grade | H1 | H1 | - | - | H1 | - | H1 | H1 | H1 |
|   | Durability factor | 0.1-9.4 | - | - | - | 0.22 | - | 0.12 | 0.1 | 0.1 |
|   | Porosity factor % | - | - | - | - | 0.01 (non-porous) | 2.9 (non-porous) | 2.0 | -0.013 (non-porous) | - |
|   | Water saturation degree % | - | - | 0.17-0.5 (low saturation) | - | - | - | - | - | - |
|   | Content of weak | - | - | - | - | 25 | - | - | - | - |
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