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Professional paper

FOLIATION IMPACT ON THE DYNAMIC PROPERTIES OF SELECTED SAMPLES OF THE BARRIER DAM SITE PRVONEK - RIGHT SIDE

UTICAJ FOLIJACIJE NA DINAMIČKA SVOJSTAVA UZORAKA IZDVOJENIH NA PREGRADNOM MESTU BRANE PRVONEK – DESNI BOK

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Abstract: The "Prvonek" dam was built in tight asymmetric Banjska river valley about 100 meters downstream from the river Gradasnica. Barrier at the dam site built predominantly slate series of high crystallinity Vranjska Banja, alternately layered double mica, gneiss, leptinolite and micaschist. For the construction of this place were carried out extensive field and laboratory geotechnical investigations. Part of laboratory geotechnical investigations related to the testing of dynamic properties in the perpendicular and parallel direction to the foliation of gneiss and micashist samples on the right side.The aim of investigations is definition of anisotropy tested dynamic parameters.

Keywords: dynamic properties, foliation, gneiss, micashist, anisotropy.

Apstrakt: Brana „Prvonek" izgrađena je u uskoj klisurastoj asimetričnoj dolini Banjske reke oko 100 m nizvodno od ušća reke Gradašnice. Pregradno mesto pretežno izgrađuju škriljci visokog kristaliteta takozvane serije Vranjske banje predstavljene naizmenično uslojenim dvoliskunskim gnajsevima, leptinolitima i mikašistima. Za potrebe izgradnje ovog objekta obavljena su obimna terenska i laboratorijska geomehanička ispitivanja, koja su vršena i tokom njegove izgradnje. Deo laboratorijskih geomehaničkih ispitivanja odnosio se na ispitivanje dinamičkih svojstava u pravcu upravno i paraleno na foliaciju uzoraka gnajsa i mikašista izdvojenih na desnom boku. Ova ispitivanja imala su za cilj definisanje anizotropije ispitivanih dinamičkih parametara.

Ključne reči: dinamička svojstva, foliacija, gnajs, mikašist, anizotropija

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1. INTRODUCTION

Earth dam "Prvonek" with clay core separates the Banjska river 100 meters downstream from the river Gradasnica. Banjska river valley is canyon type, has an asymmetrical profile, with a distinctive strom left bank, the slope is 45 to 90 degrees, a tilt to the right is 35 degrees. Alluvial valley width is 30 to 60 meters. Storage space and wider catchment area build schist Vranjska Banja series, previous to Devonian age. During the construction of the Dam were carried out investigations of samples from the right bank. On eight samples were carried out geotechnical laboratory investigations. Samples are taken in the blocks form which are formed test bodies on the basis of foliation orientation. All dynamic and static deformability parameters were tested in parallel and perpendicular to foliation. Solid rocks contain discontinuities, as discontinuum. Discontinuity can be represented through Statistics, and forming quasi homogeneous zones. Zones are used to create models. In the intermediate site and the storage area rocks foliation is present in the surface defined orientation. Determination of dynamic parameters of this type discontinuity, allow the design of optimal solutions on the right side of the barrier.

2. GEOLOGICAL DIVIDING THE BARRIER AND THE STORAGE SPACE

Storage pool and barrier built related rocks, schist Vranjska Banja series of high crystallinity, over which lie thicker and thinner layers of decoupled rocks, in the engineering-geological terms. Tectonic processes more and more deeply affected by the wall on the right bank of the river Banjstica to a depth of 20 m. On the left bank of the foliation is more favorable position and decomposition zone is shallow. Space accumulation represents a favorable environment for the formation of accumulation

Lithologic members Vranjska banja Series are:

Quartzites are milky white. They occur as lenses, rarely wires in gneisses and micashist. The thickness from a few centimeters to several tens of centimeters, rarely over 1 meter. They constructed of quartz, feldspar and sometimes contain some mica. Vranjska Banja area, barrier site and storage plase have been built from gneiss, micashist, amphibole and quartz, which are metamorphosed into amphibole facies.

Gneisses (Figure 1) are brown in color. Medium grain size of 2 to 5 millimeters, with extreme schist defined oriented biotite and muscovite leaves. They are made of feldspar, orthoclase, albite and microcline, muscovite, biotite and quartz. In these rocks are encountered, garnet, kyanite, staurolit and from accessory apatite and zircon. Structures are lepidoblastic, granoblastic and porphyroblastic. The gneisses encountered amygdala feldspar, when the rocks turn into Migmatite. There are also fine micro sets and cracks that intersect schist at different angles. It is the cleavage of the axial surface and an intermediate cleavage. The gneiss has a lens or a wire-feldspar quartz.

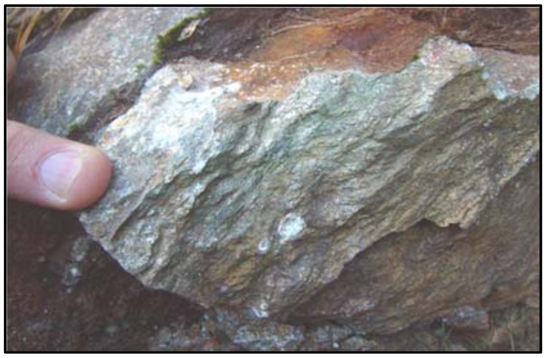

Figure 1 Prvonek dam, gneiss detail (photo D. Milovanović)

Micashist (Figure 2) are built of biotite, muscovite and quartz. Rarely in these rocks happiness porphyroblasts grenades and kyanite up to a few millimeters when the wall has a dimpled texture. Micashist have expressed king texture. In these rocks there are axial surface cleavage and interlayer cleavage, there has been a tectonic transformation along cleavage. Structures are lepidoblastic, less granoblastic and porphyroblastic. They have significantly weaker mechanical properties of gneiss. When the content of feldspar increase micashist pass into gneiss. Somewhere is a gradual transition between the wall and somewhere alternate. Wall thickness grade packages from several tens of centimeters to over 1 meter. Dismissals were the result of protolith composition, in primary wall are formed micashist, gneisses, sandstones and clays. Structures are granoblastic, textures are massive. These rocks are very hard (Vukanović, 1977).

Figure 2 Prvonek dam, micaschist (photo D. Milovanović)

Amphibolites are dark green to black. They occur as lenses or interlayers in gneiss, very rare in micashist thicknesses up to a few meters. They are built by hornblende and plagioclase. In this wall has a quartz episodes, rare and grenades. Structures are nematoblastic, rare granoblastic and porfyroblastic. The texture is slate, has a mass party of each wall. Tectonic relations are complex, with frequent lateral and vertical transitions.

Granodiorite, **dacite, quartz porphyries** are also in this area. Granodiorite dominated. They are gray, massive textures, built of biotite, hornblende, orthoclase, feldspar and quartz. Structures are grainy, sometimes porphyria. Size of minerals is about a few millimeters. Wall is fresh, just sometimes poor sericitizated and kaolinited. Secretion is plate to parallelepiped which is important for exploitation (Vukanović, 1977).

Igneous rocks are Neogene, granodiorite Surdulica and its volcanic and wired equivalent had an impact on metamorphic rocks of high crystallinity. Due to changes in thermal contact occurred recrystallization of minerals, mainly gneiss and mica or micashist.

At about 3 km upstream from the dam, there has been the borrow Neogene granodiorite (Mali and Veliki Glog) for the filling of the dam.

Quartzites are hard rocks, occur as lenses or thin wires in micashist and gneisses. They are not regular members of the lithology in this area.

Amphibolites have better mechanical properties of gneiss. They occur as interlayers and they are not regular members of the lithology in this area.

Gneisses have better mechanical properties than micashist. Micashist have the weakest mechanical properties due to the schistosity and cleavage axial surface and interlayer cleavage. Gneisses and micashist appear alternately. They also have different mechanical properties. Texture of these rocks is very important, schists, pleating and cleavage too. Schists, pleating and cleavage are predisposed routes of mechanical discontinuity. This is the most important factor of the physical and mechanical properties.

Due the process of Teuton and Orogeny rock mass is fissured. Rock mass has changed and dams, general declines towards the South-Southwest. Burst deformities are common. The faults are shorter in length from 5 to 50 meters, with a crushed zone widths up to 0.6 meters. Fissure system has 5 distinctive system.

3. LABORATORY TESTS OF THE DYNAMIC PROPERTIES

According to the research program on the right bank of the dam “Prvonek” was allocated eight samples. Samples were extracted in the form of blocks of dimensions 200 mm x 200 mm x 250 mm. On the basis of the foliation orientation of each sample is formed four test bodies. We studied the dynamic properties, Compressive Strength and static Modulus of elasticity and deformation. All parameters were tested perpendicular to and parallel to the foliation. Figure 3, shows the rock mass dividity.

Figure 3 Sampling place at the dam site Prvonek, right bank (photo D. Milovanović)

Figure 4, shows a Sample - 3, two test bodies, in which the dynamic properties (Table 1) were determined before the uniaxial compressive Strength (test body 1) and triple hysteresis (test body 2). Dynamic properties were determined in all three directions relative to the foliation. To determine dynamic properties, the timing of passage of elastic t_p longitudinal and transversal waves t_s, used Japanese production company OYO device, type SONIC WIEWER MODEL 5210, with the accuracy of reading time of 0.1 microseconds. Based on volumetric weight and knowing the velocities of longitudinal elastic waves - v_p and transversal elastic waves - v_s, is determined as a function of schists Dynamic Modulus E_{dyn} and Poisson Coefficient of dynamic μ_{dyn}.

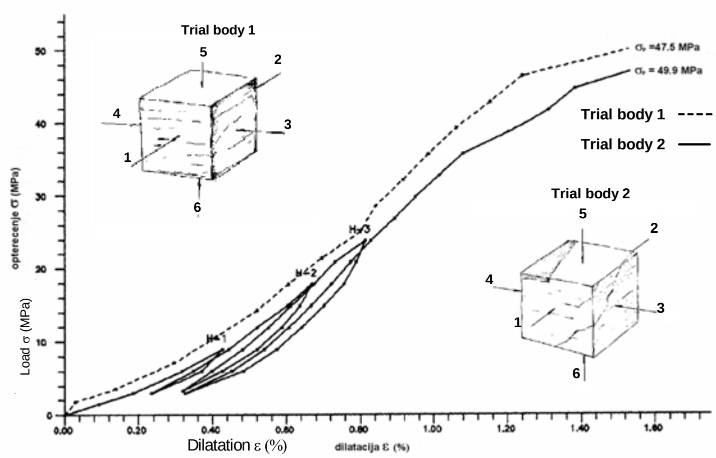

Figure 4 Sample – 3, right bank, perpedicular to the foliation, micaschist, coarse-grained, well-slate, tabular to flattened, very fresh. (Rudarsko-geološki fakultet, 1990)

Table 1 Dynamic properties Sample – 3, Load perpendicular to foliation (Rudarsko-geološki fakultet, 1990)

Trial body label	Direction label	γ (kN/m^3)	v_p (m/s)	v_s (m/s)	E_{dyn} (MPa)	μ_{dyn}
1	Parallel (1-2)	26.78	4661	2444	42 000	0.31
	Parallel (3-4)		5151	2550	46 680	0.34
	Perpendicular (5-6)		3098	1425	14 880	0.37
2	Parallel (1-2)	26.78	4667	2154	33 570	0.35
	Parallel (3-4)		4444	2222	35 320	0.33
	Perpendicular (5-6)		2630	1344	12 830	0.32

Uniaxial compressive Strength and structural properties of certain deformable are determined perpendicular to the foliation (Table 2). Triple hysteresis is carried out to determine the three levels of static Modulus of elasticity and deformation. The first Load level represents 20% of the determined value of the uniaxial pressure. Each successive level increases by 20%. Trial bodies are outlined in order to express better the direction of foliation.

Figure 5, shows dynamic and statistic parameters parallel to foliation, on a par with.

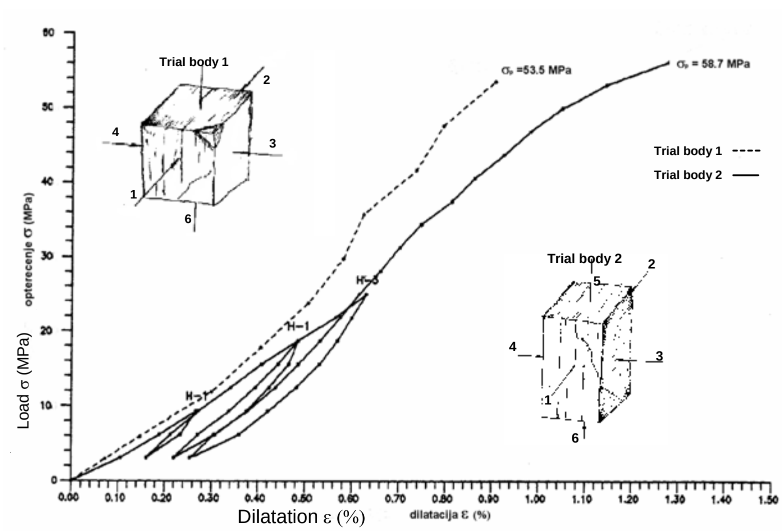

Figure 5 Sample – 3, right bank, parallel to foliation, micaschist, coarse-grained, well-slate, tabular to flattened, very fresh (Rudarsko-geološki fakultet, 1990)

Table 2 Dynamic properties Sample – 3, Load perpendicular to foliation (Rudarsko-geološki fakultet, 1990)

Trial body label	Direction label	γ (kN/m³)	v_p (m/s)	v_s (m/s)	E_{dyn} (MPa)	μ_{dyn}
1	Parallel (1-2)	26.78	4823	2158	34 360	0.37
	Parallel (3-4)		2278	1171	9 720	0.32
	Perpendicular (5-6)		5000	2500	44 720	0.33
2	Parallel (1-2)	26.78	4375	2500	42 180	0.26
	Parallel (3-4)		1525	938	56 50	0.20
	Perpendicular (5-6)		5071	2731	51 860	0.30

4. RESULTS OF DYNAMIC INVESTIGATIONS

Table 3, presents the results of a statistical analysis of the dynamic properties of the tested directions. The Coefficient of variation has a very high value if the estimate is done for the results of tests in all directions. The Coefficient of variation has a very high value if the estimate is done for the results of tests perpendicular to foliation. This shows a pronounced anisotropy of examined parameters in all directions, and perpendicular to the foliation.

Table 3 Statistical parameters of the dynamic tests results in relation to foliation (Cvetković, 2000)

Label direction	Statistical parameter	v_p (m/s)	v_s (m/s)	E_{dyn} (MPa)	Number of measurements
In all directions	Minimum	1525	2380	5650	79
	Maximum	6059	3567	76160	
	St. Deviation	1149	572	15726	
	Var. Coeff. (%)	28.90	27.37	49.98	
	Mean	3976	2090	31465	
Parallel	Minimum	1547	1160	5960	52
	Maximum	6059	3567	76160	
	St. Deviation	850	471	13540	
	Var. Coeff. (%)	18.75	19.94	34.76	
	Mean	4532	2362	38953	
Perpendicular	Minimum	1525	938	5650	27
	Maximum	4904	2229	35190	
	St. Deviation	826	334	7708	
	Var. Coeff. (%)	28.58	21.27	45.03	
	Mean	2890	1570	17117	

Anisotropy expressed perpendicular to the foliation suggests that other parameters show large differences. From Table 3, it can be seen that the dynamic parameters laid parallel to the foliation are higher than those perpendicular to the foliation. The same applies with statistical parameters (Figures 4 and 5). These tests confirm the views of the famous literature that undisturbed wall with a planar texture, especially schist have a much higher compressibility, perpendicular to the plane of texture rather than parallel to the same level (Kujundžić, 1977).

Anisotropy, which has been tested belongs to the following types of anisotropy:

- Anisotropy II level, determined through stratification and the dismissal of various lithological type, graded stratification and cracking and
- Anistoropy III level, conditional through arrangement of mineral grains, or the structure of the wall, its microcracking and is expressed as anisotropy of rock instance (Lapčević, 2004).

Figure 6, shows terrain on the right side of the dam “Prvonek”.

Figure 6 Dam “Prvonek”, right bank (photo D. Milovanović)

5. CONCLUSION

Barrier at the dam site “Prvonek” and storage Space are built of high crystallitnity schist. Left and right banks terrain has stim tilt. Due to cracking and foliated defined surfaces, is prone to erosion and disintegration under the atmospheric conditions and anthropogenic factors influence. During the construction of the dam there was a significant phenomenon of modern exodynamic processes.

Due to the extremely unfavorable position of foliation on the right bank, have fallen away, slip, and even the appearance of landslides. These phenomena have caused development of a Program of research studies in the execution time of works on the right bank of the dam “Prvonek”. Part of laboratory tests relating to the determination of the foliation impact of the geomechanical parameters. Dynamic testing of perpendicular to and parallel to foliation performed on all test bodies, after they were made static tests.

Dynamic properties revealed the pronounced anisotropy and with other parameters have led to significant changes in geometry. So that the reliable stabilization measures have been taken. Terrain on the right side of the dam is arranged.

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