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Description of Engineering-Geological Conditions of "Khobi 2 HPP" Construction Diversion Tunnel (from pk 4+200 to pk 4+500) and Assessment of Surrounding Massif

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Abstract.

Hydrotechnical facilities represent hard complex of structures, the design and construction of which requires a large volume of detailed engineering-geological substantiation. Using of water resources shall be carried out in complex and hydrographic network of our country is no exception in this regard.

The actuality of the issue is obvious; therefore, various geological processes require special study, which is necessary condition for the rational design and construction of hydrotechnical facilities. In hydrotechnical construction practice there are many cases when, due to improper assessment of geological conditions, structure deformations, failures and sometimes cataclysms took place.

The investigation territory is located in Chkhorotsku region, close to the village Mukhuri. The territory represents the hilly exposition covered with deciduous forest and is free from constructions. At the mentioned territory construction of "Khobi 2 HPP" hydrotechnical complex is considered by the project, which consists of the following: headworks, powerhouse, 6.6 km long tunnel and 0.8 km long penstock. The capacity of HPP is 45 MW.

Keywords: diversion tunnel; engineering geology; fracture; Khobi 2 HPP; rocks; tectonic fault.

Introduction

In the present article the results of engineering-geological mapping of the section from pk 4+200 to pk 4+500 of "Khobi 2 HPP" diversion tunnel and laboratory investigation of rock samples taken from the mentioned section are given.

The diversion tunnel is 6607 m long; its cross section is circular and the diameter is 3500 mm. The tunnel location depth varies from 10m to 850m. Tunneling from pk 0+000 to pk 0+018.3 was held by drilling and blastin, but from pk 0+018.3 – by TBM tunnel boring machine.

Main Part

The diversion tunnel section from pk 4+200 to pk 4+500 (300m long) is lithologically structured by greenish-dark grey and brownish-gray tuff breccias with various thicknesses, by greenish-dark grey, greenish-grey tuff sandstones, light grayish coarse and medium-grained porphyrites and dark grey tuffs. Within this section areas, thick and small tectonic fractures were observed (width of which varies from few mm to 0.1-0.6m). The fractures are filled with mineral salts, basically with calcite and partially – by clay. Most of them are closed, however, open fractures are observed as well. Surfaces of fractures are wavy and slightly rough. Length of the fractures varies within 1-3m areas; it sometimes exceeds 3m.

In the interval of the tunnel from pk 4+200 to pk 4+500, 8 sections having engineering-geological conditions, more or less different from each other, were selected. We review two of them for instance:

- Section – 1 – from pk 4+200 to pk 4+400;
- Section – 2 – from pk 4+400 to pk 4+500;

Descriptions and assessment of engineering-geological conditions of each section are given below separately:

Section – 1 – from pk 4+200 to pk 4+400 (200m long) (see Drawings ##1 – 7).

The tunnel section from pk 4+200 to pk 4+400 is lithologically structured by greenish-dark grey, strong and fine fragmental and medium fragmental tuff breccias with medium strength. I this interval from pk 4+363.5 to pk 4+378, in the arched part of the tunnel, greenish-dark grey tuff breccias with medium strength are observed.

Within this section areas some thick tectonic fractures take place; their widths exceed 100mm, in particluar:

- pk 4+352.8 dip azimuth 60^0, inclination angle 45^0, width 150-300mm, apparent length >3m, filling calcite;
- pk 4+357 dip azimuth 63^0, inclination angle 60^0, width 200-300mm, apparent length >3m, filling calcite;
- pk 4+360 dip azimuth 65^0, inclination angle 45^0, width 10-300mm, apparent length >3m, filling calcite;
- pk 4+362.5 dip azimuth 240^0, inclination angle 65^0, width 5-300mm, apparent length >3m, filling calcite;
- pk 4+369.5 dip azimuth 65^0, inclination angle 45^0, width 10-300mm, apparent length >3m, filling calcite;
- pk 4+373 dip azimuth 240^0, inclination angle 50^0, width 120-300mm, apparent length >3m, filling calcite;
- pk 4+382 dip azimuth 240^0, inclination angle 55^0, width 50-200mm, apparent length >3m, filling calcite;
- pk 4+384 dip azimuth 240^0, inclination angle 55^0, width 10-200mm, apparent length >3m, filling calcite;
- pk 4+385.5 dip azimuth 240^0, inclination angle 40^0, width 30-200mm, apparent length >3m, filling calcite;
- pk 4+398.5 dip azimuth 240^0, inclination angle 50^0, width 100-250mm, apparent length >3m, filling calcite.

On base of rocks fracturing study 3 systems of fractures [1] were selected here, including the following:

I system: dip azimuth 60^0, inclination angle 58^0, aperture width 0.1-1.0mm; average space between fractures 0.19m, apparent length >3m. Surfaces of fractures are smooth, wavy, locally slightly rough, wavy, locally smooth, fracture filling – silty-sandy-clayey. Some fractures are filled up with mineral salts, basically with calcite.

II system: dip azimuth 230^0, inclination angle 55^0, width 0.1-1.0mm; average space between fractures 0.46m, apparent length to 3m. Surfaces of fractures are wavy, smooth, locally slightly rough; filling – silty-sandy, locally clayey. Some fractures are filled up with mineral salts.

III system: dip azimuth 330^0, inclination angle 65^0, width 0.1-5.0mm; average space between fractures 0.98m, apparent length to 1m. Surfaces of fractures are slightly rough, wavy; filling – silty-sandy, locally clayey. Some fractures are partially filled up with mineral salts.

Besides above-mentioned fractures there are lots of chaotic fractures with various orientations as well in this section.

Rocks (tuffbreccias and tuff sandstones) are studied by laboratory. Average values of their physical-mechanical properties are as follows:

Tuffbreccia:

- Density _ ρ=2.61 g/cm^3;
- Point load strength _ I_{s50}=3.07 MPa [2].

According to strength the rocks are classified as strong (R=4).

Tuff sandstone:

- Density _ ρ=2.66 g/cm^3;
- Point load strength _ I_{s50}=4.30 MPa [2].

According to strength the rocks are classified as strong (R=4).

Within the section areas rock mass characteristics are as follows:

- Rock mass total rating is RMR=48-50 according to geomechanical classification;
- Quality index Q=5.99-7.97 according to which the massif is of class C (fair).

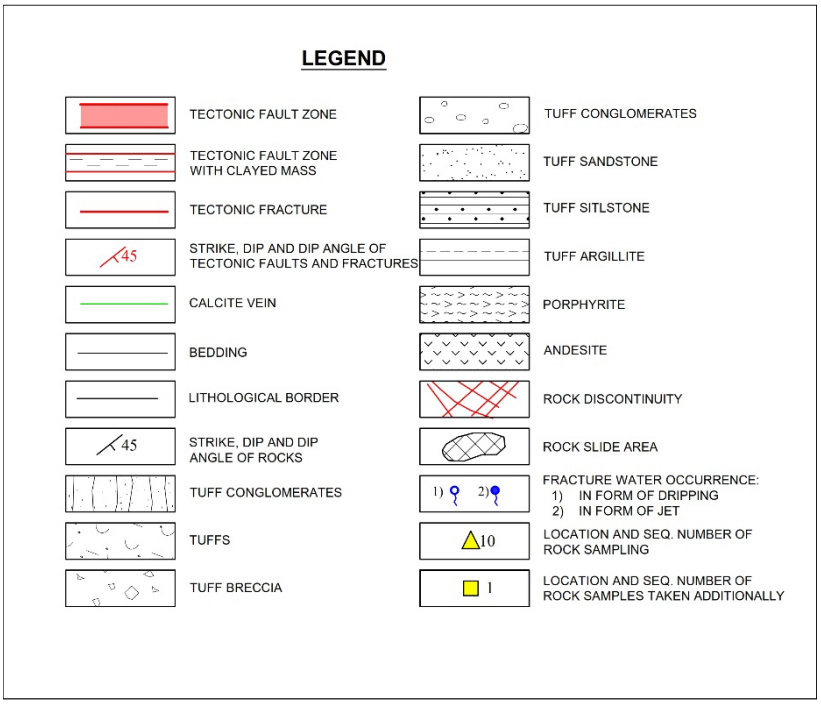
In the tunnel section from pk 4+200 to pk 4+400 water observation took place in some intervals by dripping, leakage, locally streaming or heavily dripping, but most part of the tunnel arch and walls is wet.

Water inflow is the following according to intervals: AKMAYO

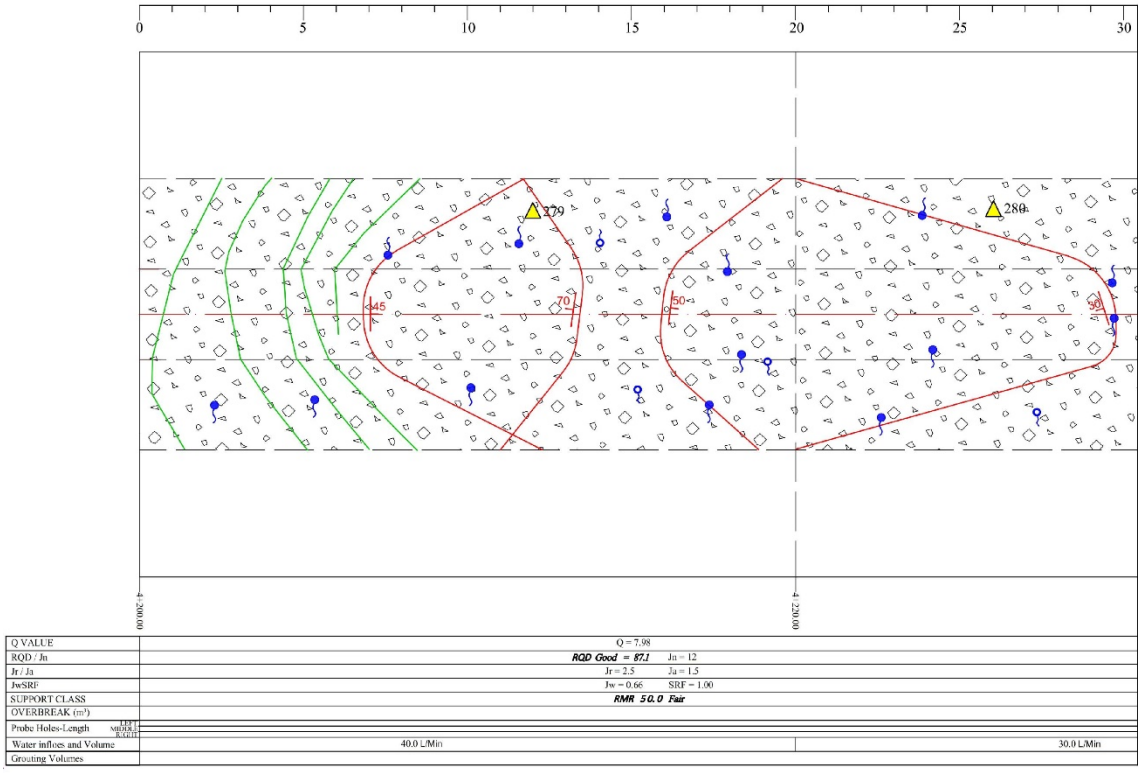
pk 4+200 ÷ pk4+220 - 40 l/min
pk 4+220 ÷ pk4+240 - 30 l/min
pk 4+240 ÷ pk4+260 - 10 l/min
pk 4+260 ÷ pk4+280 - 30 l/min
pk 4+280 ÷ pk4+300 - 20 l/min
pk 4+300 ÷ pk4+320 - 30 l/min
pk 4+320 ÷ pk4+340 - 5 l/min
pk 4+340 ÷ pk4+360 - 10 l/min
pk 4+360 ÷ pk4+380 - 20 l/min
pk 4+380 ÷ pk4+400 - 10 l/min

During tunneling the section from pk 4+200 to pk 4+400, from the tunnel arch and walls falling of rock fragments and some blocks took place, total volume of which made the following according to separate intervals:

pk4+240 ÷ pk4+260 - 1.0 m^3
pk4+280 ÷ pk4+300 - 0.10 m^3
pk4+320 ÷ pk3+340 - 0.10 m^3
pk4+340 ÷ pk4+360 - 0.10 m^3
pk4+360 ÷ pk4+380 - 0.10 m^3
pk4+380 ÷ pk4+400 - 0.10 m^3



Drawing #1



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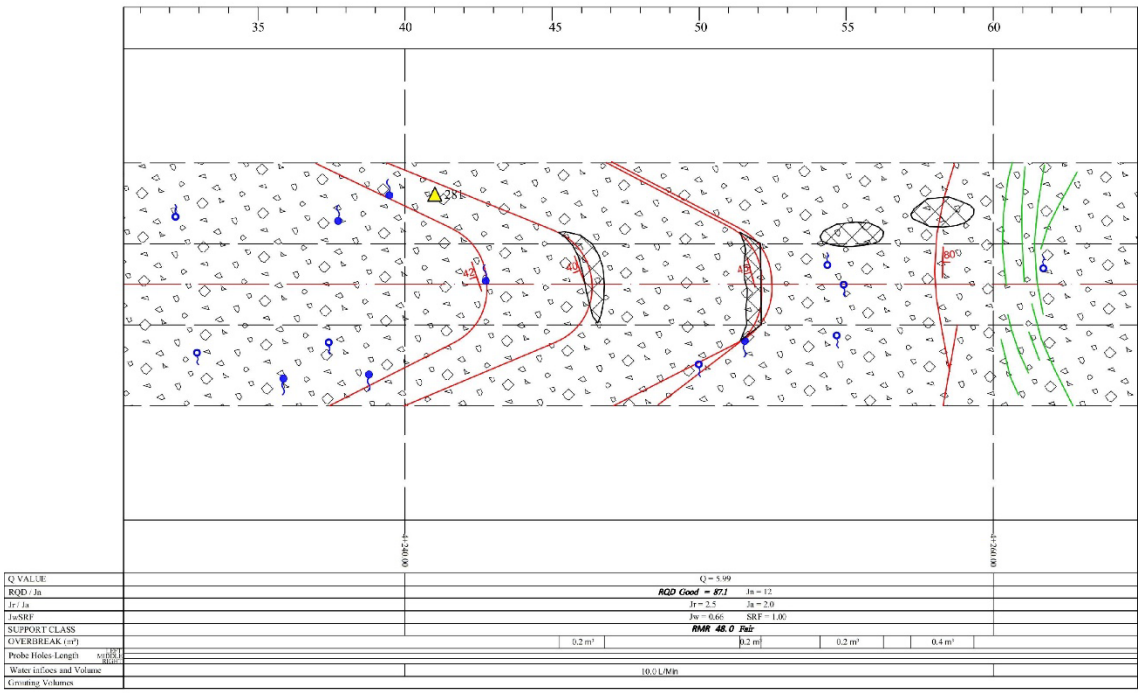

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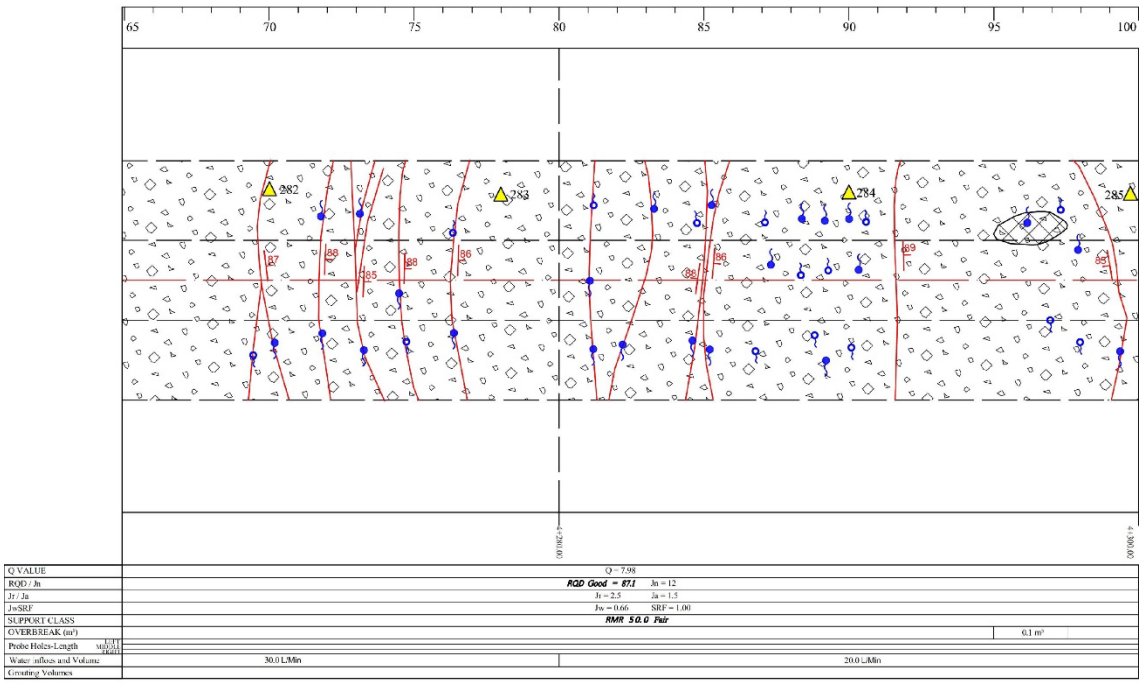

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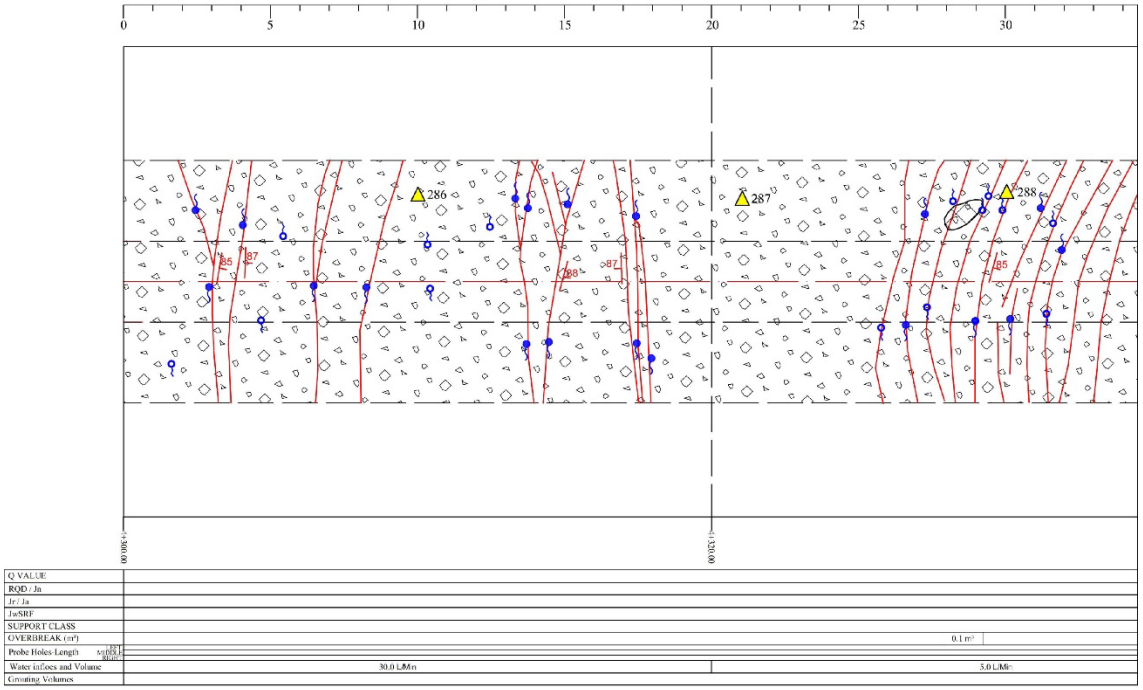

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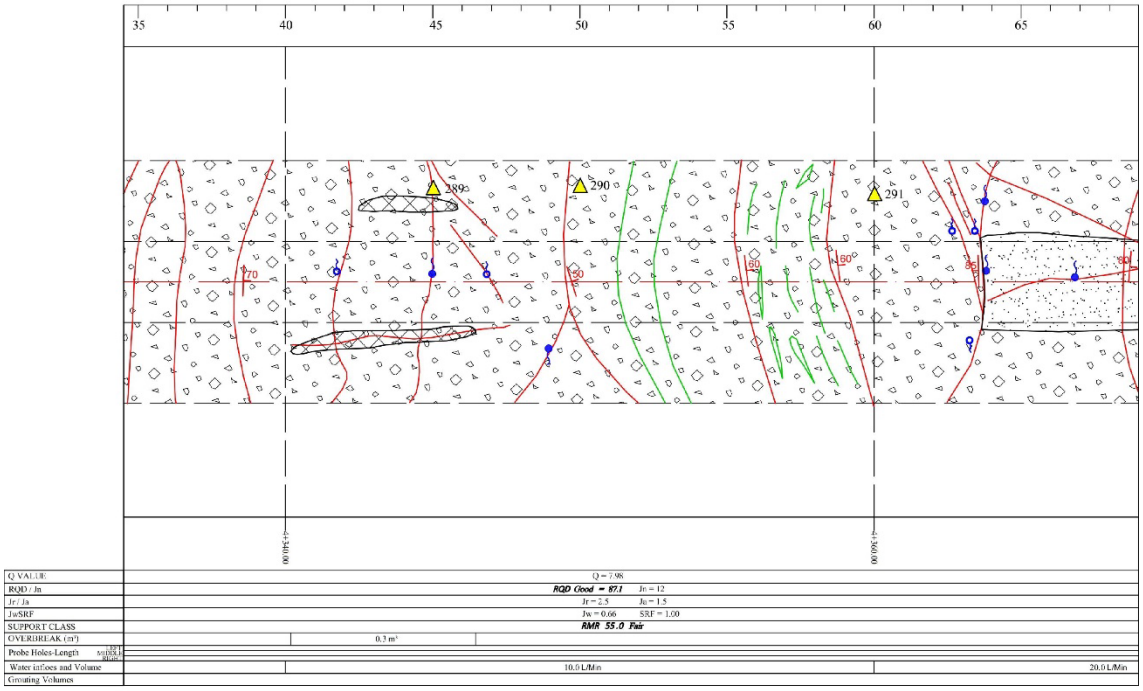
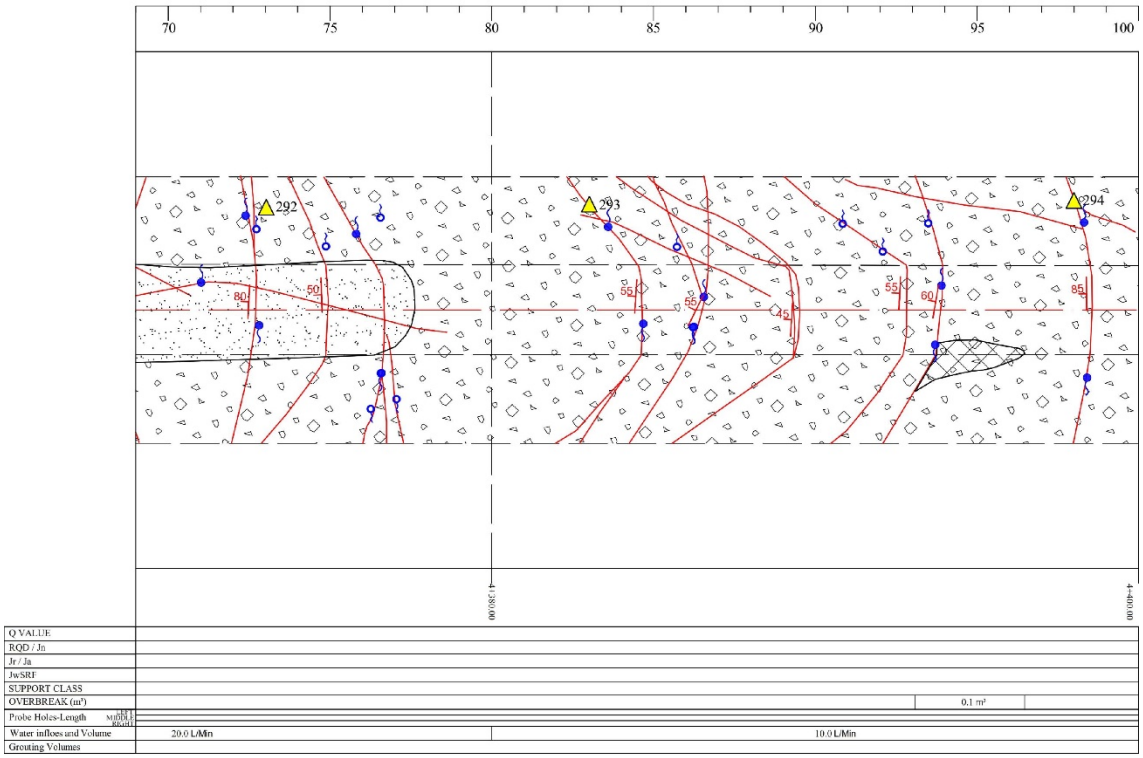


Drawing #6



Drawing #7

Section – 2 – from pk 4+400 to pk 4+500 (100m long) (see Drawings ##8-10).

The tunnel section from pk 4+400 to pk 4+500 is lithologically structured by greenish-dark grey, strong tuff breccias, tuff breccias with medium strength as well, and greenish-dark grey fine and coarse grained strong tuff sandstones.

Within this section areas tectonic fractures take place; their widths exceed 100mm, in particluar:

- pk 4+418 dip azimuth 65^0, inclination angle 45^0, width 30-120mm, apparent length >3m, filling calcite;
- pk 4+441 dip azimuth 65^0, inclination angle 45^0, width 10-200mm, apparent length >3m, filling clay, silt, sand and rarely calcite;
- pk 4+454 dip azimuth 60^0, inclination angle 25^0, width 20-200mm, apparent length >3m, filling clay and calcite;
- pk 4+468 dip azimuth 87^0, inclination angle 86^0, width 30-150mm, apparent length >3m, filling clay and calcite;

On base of rocks fracturing study 3 systems of fractures [1] were selected here, including the following:

I system: dip azimuth 65^0, inclination angle 61^0, aperture width 0.1-1.0mm; average space between fractures 0.19m, apparent length 1-3m. Surfaces of fractures slightly rough, wavy; fracture filling – hard, silty-sandy-clayey. Some fractures are filled up with mineral salts.

II system: dip azimuth 190^0, inclination angle 60^0, aperture width 0.1-5.0mm; average space between fractures 0.37m, apparent length 1-3m. Surfaces of fractures wavy, slightly rough; filling – calcite and silty-clayey.

III system: dip azimuth 320^0, inclination angle 52^0, aperture width 0.1-1.0mm; average space between fractures 0.92m, apparent length 1-3m. Surfaces of fractures slightly rough, wavy; filling – silty- clayey. Some fractures are filled up with mineral salts.

Besides above mentioned fractures there are lots of chaotic fractures as well in the massif.

Lithological varieties of rocks are studied by laboratory. Values of their physical-mechanical properties are as follows:

Tuffbreccia:

- Density _ ρ=2.60g/cm^3;
- Point load strength _ I_{s50}=2.42 MPa [2].

Tuff sandstone:

- Density _ ρ=2.66g/cm^3;
- Point load strength _ I_{s50}=6.20 mpa [2].

According to strength the rocks are classified as fair and strong (**R=3÷4**).

Within the section areas rock mass characteristics are as follows:

- Rock mass total rating is RMR=48 according to geomechanical classification;
- Quality index Q=5.85 according to which the massif is of class C (fair).

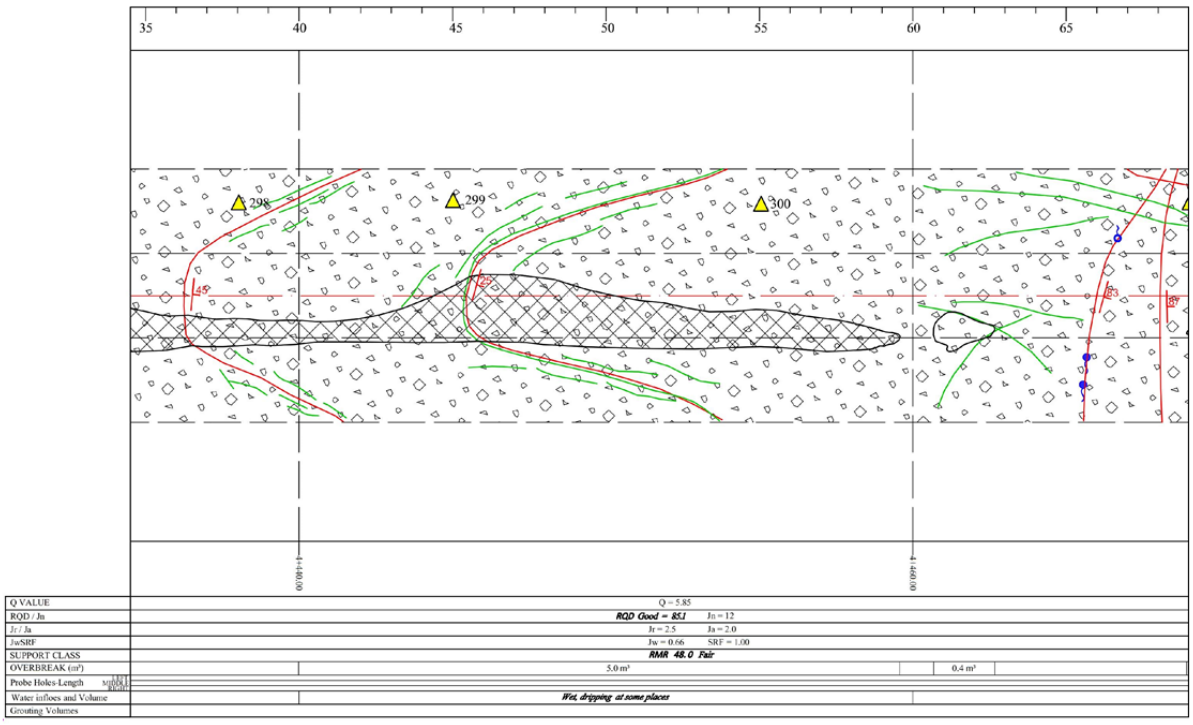
In the tunnel section from pk 4+400 to pk 4+155 water observation took place in some intervals by dripping, leakage, locally streaming or heavily dripping, but most part of the tunnel arch and walls is wet.

Water inflow is the following according to intervals:

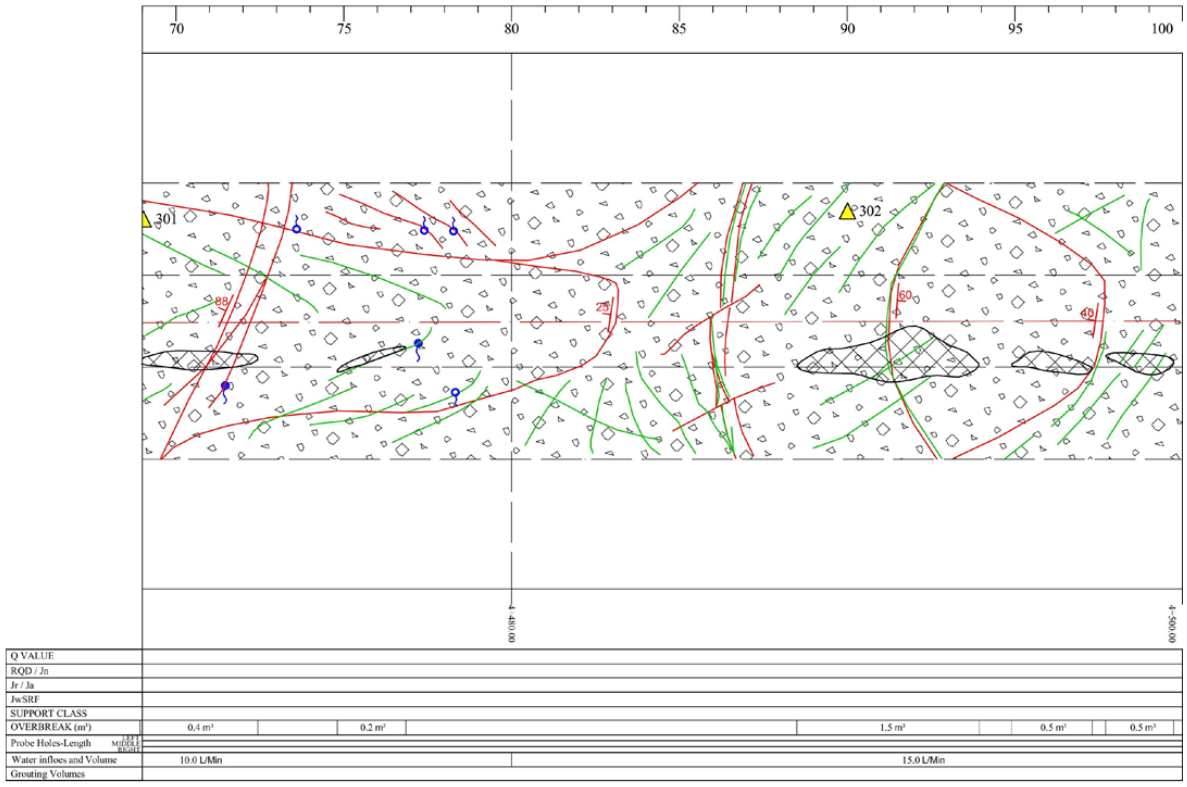
pk 4+400 ÷ pk 4+420 - 10 l/min
pk 4+420 ÷ pk 4+440 - 15 l/min
pk 4+460 ÷pk 4+480 - 10 l/min
pk 4+480 ÷ pk 4+500 - 15 l/min

During tunneling the section from pk 4+400 to pk 4+500, from the tunnel arch and walls falling of rock fragments and some blocks took place, total volume of which made the following according to separate intervals:

pk 4+400 ÷ pk 4+420 - 5.0m^3.
pk 4+420 ÷ pk 4+440 - 4.0 m^3
pk 4+440 ÷ pk 4+460 - 5.0 m^3
pk 4+460 ÷ pk 4+480 - 1.0 m^3
pk 4+480 ÷ pk 4+500 - 2.50 m^3



Drawing #9



Drawing #10

Conclusion

1. Diversion tunnel of "Khobi 2 HPP" is structured by: strong tuff sandstones, crystalloclastic tuffs and tuff breccias. Dispite the rocks are fractured and some thick tectonic fractures are observed, rock massif makes good, liable conditions for the tunnel exploitation;
2. In the interval of the tunnel from pk 4+200 to pk 4+500, 8 sections having engineering-geological conditions, more or less different from each other, were selected;
3. On base of rocks fracturing study 3 systems of fractures were selected in interval from pk 4+200 to pk 4+500 of the tunnel;
4. In the tunnel section from pk 4+400 to pk 4+400 water observation took place in some intervals by dripping, leakage, locally streaming or heavily dripping, but most part of the tunnel arch and walls is wet.
5. During tunneling the section from pk 4+200 to pk 4+400, from the tunnel arch and walls falling of rock fragments and some blocks took place.

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„ხობი 2 ჰესის“ მშენებარე სადერივაციო გვირაბის (პკ 4+200-დან პკ 4+500-მდე) საინჟინრო-გეოლოგიური პირობების აღწერა და გარემომცველი მასივის შეფასება

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ანოტაცია. ჰიდროტექნიკური ობიექტები ნაგებობათა რთული კომპლექსია, რომელთა დაპროექტება-მშენებლობა დიდი მოცულობის დეტალურ საინჟინრო-გეოლოგიურ დასაბუთებას მოითხოვს. წყლის რესურსების გამოყენება კომპლექსურად უნდა ხდებოდეს და ამ მხრივ გამონაკლისი არც ჩვენი ქვეყნის ჰიდროგრაფიული ქსელია.

საკითხის აქტუალურობა თვალსაჩინოა, ამიტომ განსაკუთრებულ შესწავლას მოითხოვს სხვადასხვა გეოლოგიური პროცესი, რაც აუცილებელი წინაპირობაა ჰიდროტექნიკური ობიექტების რაციონალურად დაპროექტებისა და მშენებლობისათვის. ჰიდროტექნიკური მშენებლობის პრაქტიკაში მრავლადაა ისეთი შემთხვევები, როდესაც გეოლოგიური პირობების არასათანადოდ შეფასების გამო, ადგილი ჰქონდა ნაგებობის დეფორმაციებს, ავარიებს და ზოგჯერ კატაკლიზმებს.

საკვლევი ტერიტორია მდებარეობს ჩხოროწყუს რაიონში, სოფელ მუხურის მახლობლად, ტერიტორია წარმოადგენს მთა-გორიან ფოთლოვანი ტყით დაფარულ ექსპოზიციას და იგი თავისუფალია ნაგებობებისაგან, აღნიშნულ ტერიტორიაზე პროექტით გათვალისწინებულია „ხობი 2 ჰესის“ ჰიდროტექნიკური კომპლექსის მშენებლობა, რომელიც შედგება: სათავე კვანძის, ჰესის შენობის, 6.6 კილომეტრი სიგრძის გვირაბის და 0,8 კილომეტრამდე სიგრძის სადაწნეო მილსადენისაგან. ჰესის სიმძლავრე 45 მეგავატია.

საკვანძო სიტყვები: კლდოვანი ქანები; ნაპრალი; სადერევაცო გვირაბი; საინჟინრო გეოლოგია; ტექტონიკური რღვევა; ხობი 2 ჰესი.

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