ESTIMATING BLOCK VOLUMETRIC PROPORTION OF BIM ROCK IN MOGLICE HPP TUNNEL ALIGNMENT

Megi RUSI[1]

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ABSTRACT

For Moglica-Grabova tunnel, which is part of Devoll Hydropower Project in Albania, two techniques of tunneling are planned: TBM for the Flysch series starting in Moglicë and Drill & Blast for the Ophiolite section, starting in Grabova. Between Grabova and Moglica there is a section of the tunnel which will pass through a heterogeneous rock mass composed of blocks of different lithology and a fine matrix. For the characterization of this section of the tunnel and for the selection of the appropriate method, the block volumetric proportions need to be assessed. The purpose of this paper is to present three methods used for estimation block volumetric proportions in this area the results obtained and their interpretation.

Key words: BiM Rock, Volumetric Proportion, Linear Proportion, Scan Line.

1. INTRODUCTION

1.1 DESCROPTION OF THE PROJECT AND ENCOUNTERED PROBLEMS

The Moglica Hydroelectric Project is part of a Hydropower cascade planed on Devoll River which will utilize a head of 300m along an about 22 km long stretch of the River between 650 m a.s.l. and 350 m a.s.l.. The intake is situated upstream the 140 m high rock fill dam planned at Moglica. The powerhouse is located in an underground cavern on the east bank of Devoll River and has two Francis units with total capacity of 165 MW. Transmission voltage is 220 kV and estimated average annual energy production is 452 GWh. The tailrace outlet is at the upper end of the reservoir created by a 50 m high dam planned at Kokël. Approximately 11.7

[1]**Dr. Cand. Megi RUSI**, megirusi@yahoo.com,
Metropolitan University of Tirana, Department Of Civil Engineering,www.umt.edu.al.
Adress. Rr. Brigada e VIII, Vila Nr 3. Tirana, Albania.

km of tunnels with a diameter of 5.4m will be excavated in different rock masses and approximately 700m of which will pass throw BiM rocks and mélanges. Block-in-matrix rocks (BiM rocks) are mixtures of hard blocks embedded in weaker and finer matrix that are very difficult to characterize. Estimating Block Volumetric Proportions in these rock types is one of the most important properties for their characterization and the evaluation of the behavior of the overall rock mass.

2. VOLUMETRIC BLOCK PROPORTION AND SELF SIMILARITY

The proportion between block and matrix is a very important index for the characterization of heterogeneous rock masses because based on the value it is possible to judge on the mechanical behavior of the overall massive. (Uanderwood, 1970) For more information this properties can be correlated with other parameters such as uniaxial compressive strength and block size distribution. A relatively small block and matrix proportion indicates that very large blocks are isolated within the rock mass which is mostly composed of matrix and a large number of very small blocks. The overall rock mass in this case will behave like the matrix. An average value of the proportion, practically less than 43 % indicates that the blocks of massive tend to be supported by the matrix and have no contact with each other. In cases where this proportion is higher than 50 % but less than 67 %, blocks tend to contact each other. In cases where the proportion is greater than 75% the overall behavior of the rock mass will be similar to the one of the blocks. Anyhow the boundary percentage where blocks are considered to 'contact' each other depends on the shape and the size distribution of the blocks (Laznicka, 1988).

Most of the times Mélanges and Block in Matrix rocks are considered heterogeneous, but several scientific works have shown and proved that many chaotic geological processes have self-similarity in different scales (Lindquist, 1991). These discoveries have a great practical impact because by having comprehensive data in a smaller scale it is possible to predict an overall rock mass behavior (Medley, Goodman 1994). These discoveries have crucial practical applications.

Three set of data have been used in this paper for the evaluation of the true volumetric proportion of the blocks which include surface scan lines, linear drill core from the boreholes and surface mapping.

2.1 Linear Block Proportions from Core Drillings

Both measurements from geological drilling as well as from scanning lines on the map are intended for the calculation of the linear block proportion. Linear portions of blocks for each line or geological drilling are calculated as the total length of scan lines intersected blocks divided by the total geological drilling length or model scan line.
Linear block proportions are calculated for the drillings located in the area of the block in matrix massive as well as modeled scan lines on the superficial map. The requirement for the data to be considered sufficient is that the scan line length should be at least 10 times the maximum diameter of the encountered block.
The volumetric portions calculating procedure initially is carried out in the cores of Shemsit geological drilling, which is considered the most representative drilling in the area because it is located in the center of the block and matrix massive. The total drilling length is 93m and the maximum size of the encountered block in this drilling is about 3 meters.

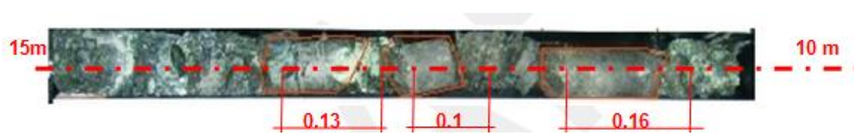

Figure 1.Shemsit Drilling Block length measurement for linear proportion calculation (Devoll HPP, 2011)

The scan line crosses through the axis of the drilling and the lengths of line interrupting each individual block are measured as shown in Figure.1. In this geological drilling the calculated linear portion of blocks is about 36%, a value which makes the block proportion geotechnically important for the overall massive see Table 1.

Table 1. Summarized data for calculating linear proportions from Shemsit drilling (Rusi M., 2016)

Drill Hole	Shemsit
Total Drilling length (m)	93
Total number of measured blocks	114
Total length of blocks (m)	33.518
Maximum block size (m)	2.977
Minimum block size (m)	0.06
Mean block size (m)	0.29
Linear Block Proportion (%)	36

2.2 Linear Block Proportions from Scanlines

The procedure of calculating the volumetric portions from scan lines is performed on the superficial map with the identified blocks from the field inventory. Measurements were conducted on 5 scan lines which include a total length of 4000m as shown in Figure 2. Scan lines are selected parallel to each other with a distance of almost 300-400meters. The largest identified Block on site has a maximum dimension of about 450 m.

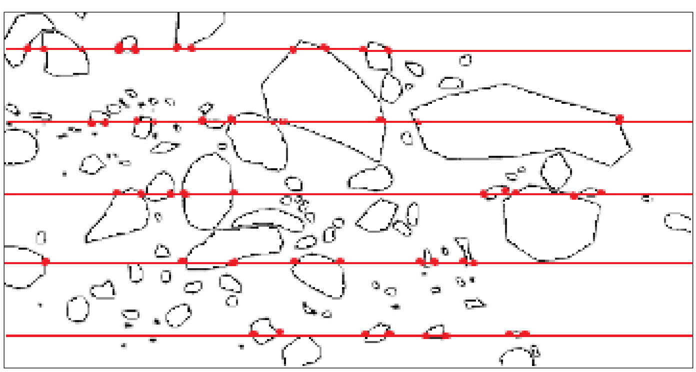

Figure 2. Scan lines in the surface map for calculating linear block proportion (Rusi M., 2016)

In order to satisfy the requirement that the scan lines should include a length of minimum 10 times the maximum diameter of the block, we selected 5 scan lines each with a fixed length of 800m. From calculations carried out on the intersection lengths of blocks with the total length of each line we have obtained linear portions of the blocks ranging from 14% to 26% as shown in Table 2. The estimated average proportion from 4000 meters of scan lines resulted about 20%.

Table 2. Summarized data for calculating linear proportions from Surface Scan lines (Rusi M, 2016)

Scan Line nr	Scan Line length (m)	Nr of Blocks	Maximum size (m)	Minimum size (m)	Measn size (m)	Total length of intersections (m)	Linear Proportions (%)
Line 1	800	21	20.8	1.1	5.2	108.1	14
Line 2	800	18	35	2.2	11.4	204.5	25.6
Line 3	800	12	35.1	4.6	12.9	155.3	19.4
Line 4	800	4	52.1	8.6	34.1	136.5	17
Line 5	800	3	149	2.6	55.5	166.5	21

This value is smaller than the value obtained from the linear proportions calculated from geological drilling but this small change can be explained by the difficulty of identification in the field some block due to the difficult topography and dense vegetation.

2.3 Surface Block Proportion From Superficial Mapping

Surface proportions can be calculated if the image or superficial map has a sufficient number and total length of scan lines. There are some suggestions as for the necessary lengths of scan lines to compute surface proportions of blocks. The more appropriate suggestion is that which recommends that the total length of scan lines used for calculations should be about 100 times larger than the average size of the blocks in the scanned area.
A more practical way is to calculate the surface of all the recorded blocks and to divide the sum value by the total surface of the heterogeneous rock mass. After performing the necessary calculations it is noted that the values for the surface proportions of the blocks are at the minimal range of values obtained from linear proportions of scan lines.
The surface of 101identified blocks is measured in AutoCAD, together with the total surface and the surface proportion of the blocks was calculated approximately 14%, results are summarized in Table 3.

Table 3. Summarized data for calculating surface proportions from surface measurements (Rusi, 2016)

Total surface (m^2)	Number of Blocks	Maximum Surface (m^2)	Minimum Surface (m^2)	Mean Surface (m^2)	Total surface of Blocks (m^2)	Surface Proportions (%)
1006921	101	98402	2	1396.2574	141022	14

3. BLOCK VOLUMETRIC PROPORTION

As mentioned above the volumetric proportions of blocks in chaotic blocks must necessarily be defined because it helps in predicting the geo mechanical behavior of the mass. Volumetric proportions are defined by the principle self-similarity with the surface and linear proportions calculated above from geological drilling and scan lines on the surface.
Given that the blocks in this rock mass don't have a uniform shape and distribution, the linear and surface proportions do not fully comply with the volumetric proportions, but there will be a value of ambiguity and error. Especially for the surface data where the technical conditions affect the collection of information. This error depends on the total linear measurement length and the linear proportion of the block itself.
The real volumetric proportion of blocks is within the range defined by the limits of ratios adjusted to the maximum and minimum volumetric blocks.
These volumetric proportions adjustment should be seen in two aspects. The first aspect is the connection of this parameter with the strength of the overall rock mass and in this aspect is discrete and conservative to apply a reducing safety factor that modifies and adjusts the volumetric proportion calculation (Medley, 1997). On the other hand, in terms of results to economic consequences of underestimating the volumetric proportions especially in the field of tunneling, it is discrete and conservative to use a magnifying factor in the calculated value.
Practically to obtain the volumetric proportions of blocks from the above calculated linear proportions, initially some adjustments should be made in the value of proportion through a linear graph. Firstly the N value should be calculated (N d max). As explained above d max is the maximum size of the block which is identified 3mfor the geological drilling and149m for scan lines. The maximum length for Shemsit drilling is 93m, while for the scan lines are4000m. To calculate the N value we divided the value of total length with the total length of the intersected blocks. For Shemsit drilling we obtained an N value of 31 see Table 4 while for the scan lines we obtained an N value of 26.

Table 4. Summarized data for calculating N value (Rusi M., 2016)

Linear Proportions (%)	Total Length (m)	Maximum Block (m)	N-value	Linear Proportion of Blocks
Drillings	93	3	31	36
Scan lines	4000	149	26	20

In order to obtain the real range of values for the volumetric proportions it is necessary to multiply the value of the calculated linear proportions by the factor of uncertainty corresponding to the N value taken from the chart in fig 3 and the product is subtracted from the original value of linear proportions for the lower limit while the product is added to the initial value of the linear proportions to determine the upper limit (De Hoff, 1986).

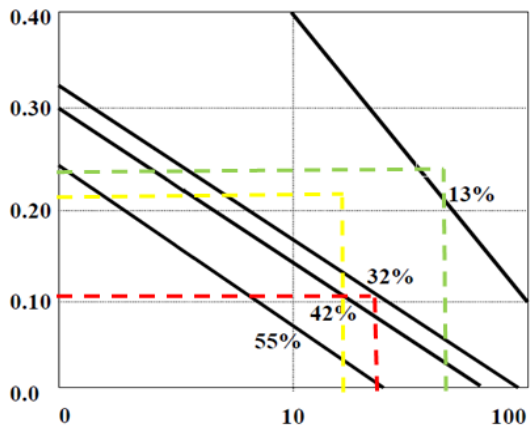

Figure 3. Uncertainty factor calculation from linear measurements and N value (Medley, 2002)

The red line in fig 3 shows the use of the chart for the uncertainty factor values obtained from geological drilling of Shemsit while the yellow line shows the values obtained by the scan lines on the surface map, the green line correspond to the surface proportion data. The obtained values of the safety factor are used to calculate the ranges of volumetric proportion summarized in the table below. True volumetric proportions will include an intermediate value of these limits defined and summarized in Table 5.

Table 5. Summarized results and the upper and lower limits of block volumetric proportions (Rusi M, 2016)

Linear Proportions (%)	N-value	Proportion of Blocks	Uncertainity Factor	Linear Proportion x Uncertainity Factor	Upper Limit of Volumetric Proportion	Lower Limit of Volumetric Proportion
Drillings	31	36	0.11	3.96	39.9	32.04
Scan lines	26	20	0.22	4.4	24.4	15.6
Surface	70	14	0.24	3.36	17.36	10.64

4. CONCLUSIONS

The block volumetric proportions of the Block and Matrix rock mass in Shemsit area have been defined on the basis of three direct calculations, surface scanning lines, geological drillings and surface mapping. Through these techniques it has been possible to measure the maximum observed size of blocks and the total length of scan line/ drill core or total surface area of mapping and thus linear and surface proportions are calculated for each case. Based on the principles of stereology for self-similarity volumetric proportions have been calculated and corrections were performed in order to get real results. The volumetric proportion of the studied area ranged from 11 % to 40 %, which means that the block volumetric proportion ratio has a geotechnical importance and massive does not behave like the matrix neither like the blocks. Previous studies have proved that a volumetric proportion of less than 25% will result in an overall rock mass behavior similar to that of the matrix, while a proportion of more than 75% will result in a behavior similar to that of the blocks. In this case the rock mass behavior is very complex and should be considered in accordance with other criteria such as 3D block size distribution, mechanical contrast between rock and matrix etc.

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