DIU Journal of Science and Technology Volume 12, Issue 1, January 2017

2017-01

Determination of Rock Discontinuity for Prediction of Blasting Performances Using Quantitative and Qualitative Parameters

Alaba, O.C.

Daffodil International University

DETERMINATION OF ROCK DISCONTINUITY FOR PREDICTION OF BLASTING PERFORMANCES USING QUANTITATIVE AND QUALITATIVE PARAMETERS

O.C. Alaba[1], T.O. Adeniyi[1], S.A. Agbalajobi[2]

[1]Department of Mineral Resources Engineering, Kwara State Polytechnic, Ilorin, Nigeria
[2]Department of Mining Engineering, Federal University of Technology, Akure, Nigeria

E-mail: alab1m@yahoo.com, tptwo2003@yahoo.com, ayodele2kid@gmail.com

Abstract: *The study assesses quantitative and qualitative parameters of rock discontinuity in some selected quarries in Ekiti and Ondo state for prediction of blasting performances. Scanline method of discontinuity measurement was used to measure 200 discontinuities from RCF granite quarry, 99 discontinuities from Kopek granite quarry and 303 discontinuities from Samchase granite quarry at a distance of 20m, 25m and 20m from each quarry bench face. Quantitative and qualitative discontinuities parameters were measured and the values obtained were recorded in frequency table with class intervals of 10-100 for dip angle, 0.01 - 0.10m for spacing and 0.01 - 0.25m for persistence. The graphs of frequency against discontinuity values were plotted. The results show that the mean spacing of the three granite quarries outcrop (357mm, 337.8mm and 343.4mm) were within 200mm - 600mm [1]discontinuity spacing classification table which indicates that the outcrops were moderately spaced. Also, the persistence values of the granite quarries outcrop (1.0019m, 1.4205m and 1.4205m) were within 1m - 3m [1] discontinuity persistence classification table which indicates that the outcrops have low persistence. The quarries have rock masses of high uniaxial compressive strengths (152.320MPa, 132.256MPa and 120.973MPa) and high point load strengths (13.732MPa, 9.713MPa and 1.953MPa). The moderately spaced outcrop, low persistence outcrop and high strengths outcrop indicates good blast performance for the three quarries.*

Keyword: *Blasting Performance, Scanline, Discontinuity, Quarries, Uniaxial Compressive Strength*

1. Introduction

[2] defined rock as aggregates of crystals and amorphous particles jointed by varying amount of cementations materials. Hence, rocks are made up of homogenous minerals such as Feldspar, Quartz, Muscovite, Biotite Hornblende, and Olivine. Rock is made up of minerals of more or less invariable composition bounded together by forces of molecular interaction (cohesion) that either at the sites of direct contact of mineral with one another or at the sites of their contact with mineral particles extraneous cementing substances [3]. A common feature of accessible rocks is that they are broken up by discontinuities and that fluid under pressure is frequently present both in open joint and in the pores of itself. Because of the nature of deposition of rock aggregates, the lithology varies and so many rocks can be encountered at a time. According [4] mechanically, rocks are classified as rock mass and intact rock (rock without discontinuity). Rock mass may look upon as discontinum of rock materials transcended by discontinuities [2]. Rock mass behaviour is dependent of the spacing, frequency, persistence and characteristics of discontinuities present. Intact rock according to [2], may be considered as continum or polycrystalline solid constituting aggregate of minerals or grains. Intact rock properties are influenced by physical properties of materials that made-up the rock and the manner they were bonded together.

Discontinuity is any significant mechanical break or fracture of negligible or low tensile strength in rock. Discontinuities in rocks are characterized by negligible tensile strength and very little shear strength [5]. A discontinuity represents a plane of weakness within a rock mass across which the rock material is structurally discontinuous [2]. Discontinuities types and origins that are

Date of submission : 13.02.2017 Date of acceptance : 01.07.2017

predominant in rocks are of interest in surface mining, rock mechanics and geotechnics and they include faults, beddings, joints and cleavages [6]. Discontinuities parameters that are essential for quantitative and qualitative analysis either mathematically, vectorial or statistically, as stated by Priest and Hudson [7] and adopted by [1] are orientation, spacing, frequency and persistence.

Discontinuity can be analyzed quantitatively using stereographical projection, vector analysis and graphical representation. Stereographic projection is a procedure for mapping data located on the surface of a sphere to horizontal plane and can be used for the orientation of planes, lines and forces [8] while qualitative analysis of discontinuity deals with the analysis of discontinuity parameters such as spacing, frequency and persistence using mathematical methods, statistics, probabilistic theory and vector analysis [9]. Discontinuities parameters influences rock strength that is useful for prediction of blasting performance and analysis of slope in underground workings [1]. Characterization of rock mass depends not only on the nature of the rock materials but also on discontinuities which are pervasive throughout rock masses [10]. In rock mining operations, the presence of discontinuities sets in rock mass induces anisotropic response of rock to loading and unloading [11]. This research work was carried out to analyze measured quantitative and qualitative parameters of rock discontinuity before blasting take place.

2. Material and Methods

2.1 Description of the Study Area

The three granite deposits are located within Ekiti and Ondo state. The first granite deposit is at RCF Quarry, geographically located between longitude 5° 6’ 33.61”E and 5° 7’ 18.31E and latitude between 7° 45’ 45.7”N and 7°44’ 58.41’’N. The quarry operates on 65 Acre of land at Oke - Iya Village, along Ara - Awo road, in Ijero Local Government Area of Ekiti State while the second granite deposit is at Kopek Quarry, geographically located between longitude 5° 16’ 33.92”E and 5° 16’ 33.98” E and latitude between 7° 29’ 10.85”N and 7° 29’ 10.91” N. The quarry operates on 74 Acre of land along Ise - Ikere road, in Ikere Local Government Area of Ekiti State and the third granite deposit is at Samchase Nigeria Limited Quarry, geographically located between longitude 5° 15’ 9.91” E and 5° 15’ 9.96” E and latitude between 7° 22’ 49.20”N and 7° 22’ 49.28”N. The coordinates of the study area location is show in Table 1 below. The quarry operates on 80 Acre of land along Itaogbolu - Akure road, in Akure North Local Government Area of Ondo State, Nigeria. The three granite quarries fall under the older granite complex of the basement complex of Nigeria. The emplacement of these older granite rocks marked the culmination of an Orogeny [12] and took place mostly during late and post tectonic periods. The specific gravity of the granite rock in RCF quarry is 2.70kg/cm^3 while that of Kopek quarry is 2.51kg/cm^3 and Samchase quarry is 2.64kg/cm^3 thereby falling between 2.516kg/cm^3 – 2.809kg/cm^3 granite specific gravity classifications. Rocks types that are predominant in the study areas are coarse porphyritic biotite granite and coarse porphyritic biotite-muscovite granite respectively [13].

2.2 Data Collection and Analysis

The field data were obtained using compass clinometer, GPS and measuring tape. Scan lines was set out at exposed rock faces and discontinuities measurements were taken. Global position system was used to read exact geographical locations of the study areas. Compass clinometer was used for orientation measurements of discontinuities that intersected the scan lines. The dip direction measurement was taken using the outer scale of the compass clinometer calibrated between 00 - 3600 while the dip angle measurement was taken using the inner scale calibrated between 00 - 900. A total of 200 angular measurements data was acquired at the bench face of 20m width in RCF quarry, 99 angular measurements data at the bench face of 25m width in Kopek quarry and 303 angular measurements data at the bench face of 20m width in Samchase quarry. Total spacing between two adjacent discontinuities was measured using a measuring tape that was placed parallel to the scan line and perpendicular to discontinuities that intersected the scan line. A total of 200 linear measurements data was acquired at the bench face of 20 m width in RCF quarry, 99 linear measurements data at the bench face of 25 m width in Kopek quarry and 303 linear measurements data at the bench face of 20 m width in Samchase quarry. The persistence of all discontinuities that intersected the scanlines was measured using semi-trace length method. Using a measuring tape, the persistence of discontinuities below and above the scan line was measured and recorded according. A total of 200 trace length measurements data was acquired at the bench face of 20 m width in RCF quarry, 99 trace length measurements data at the bench face of 25m width in Kopek quarry and 303 trace length measurements data at the bench face of 20m width in Samchase quarry. Total frequency, which is number of discontinuities intersecting a unit length of the scan line, was taken. The number of discontinuities that intersected a scan line over a unit meter was counted and recorded down as the total discontinuity frequency. The data obtained were analyzed using statistical estimation (tools).

Laboratory work was carried out using uniaxial compression machine and point load testing machine to determine the uniaxial compressive strength and point load strength of the rocks in the three quarries in accordance with ISRM and ASTM D2938 standard.

3. Discussion of the Results

3.1 RCF Quarry

Table 2 show the dip angle data classification and they were grouped with class interval of 100. It was shown that the most frequent value of the outcrop dip angle was 45 and falls between the modal class 610 – 700 of 200 discontinuity measurements

Table 1 Location of Study Area

Study Area	Longitude	Latitude	Location
RCF Quarry	5°6'33.61"E 5°7'18.31"E	7°45'45.74"N 7°44'58.41"N	The quarry operates on 65 Acre of land at Oke - Iya Village, along Ara - Awo road, Ara in Ijero Local Government Area of Ekiti State, Nigeria.
Kopek Quarry	5°16'33.92"E 5°16'33.98"E	7°29'10.85"N 7°29'10.91"N	The quarry operates on 74 Acre of land along Ise - Emure road, Ikere in Ikere Local Government Area of Ekiti State, Nigeria
Samchase Nigeria Limited Quarry	5°15'9.91"E 5°15'9.96"E	7°22'49.20"N 7°22'49.28"N	The quarry operates on 80 Acre of land along Itaogbolu - Akure road, Itaogbolu in Akure North Local Government Area of Ondo State, Nigeria

Table 2 Dip Angle Classification for RCF Quarry

Class Interval (Dip Angle) in Degree	Frequency(f)	Cumulative Frequency
1 – 10	15	15
11 – 20	20	35
21 – 30	32	67
31 – 40	25	92
41 – 50	20	112
51 – 60	15	127
61 – 70	45	172
71 – 80	28	200

Table 3 shows the total spacing data classification and they were grouped with class interval of 0.1m. It was shown that the most frequent value of the outcrop total spacing was 42 and lies between the modal class of 0.11m - 0.20m. The total discontinuity spacing distributions of the outcrop was not evenly spaced. The mean spacing of the outcrop was 0.3570m (357 mm) which means the outcrop was moderately spaced and falls within 200 mm - 600 mm [1] Discontinuity Spacing Classification Table. With moderately spaced discontinuities, good blast performance will be achieved. The rock masses are less susceptible to infill with materials and water, therefore strength reduction and weathering through these processes are uncommon.

Table 3 Total Spacing Classification Table for RCF Quarry

Class Interval (Total Spacing)	Class Mark (x)	Frequency (f)	Fx	Cumulative Frequency	x – X	$(x–X)^2$
0.01 – 0.10	0.055	34	1.870	34	-0.3020	0.0912
0.11 – 0.20	0.155	42	6.510	76	-0.2020	0.0408
0.21 – 0.30	0.255	29	7.395	105	-0.1020	0.0104
0.31 – 0.40	0.355	25	8.875	130	-0.0020	0.0000
0.41 – 0.50	0.455	16	7.280	146	0.0980	0.0096
0.51 – 0.60	0.555	18	9.990	164	0.1980	0.0393
0.61 – 0.70	0.655	12	7.860	176	0.2980	0.0888
0.71 – 0.80	0.755	8	6.040	184	0.3980	0.1584
0.81 – 0.90	0.855	5	4.275	189	0.4980	0.2480
0.91 – 1.00	0.955	5	4.775	194	0.5980	0.3576
1.01 – 1.10	1.055	4	4.220	198	0.6980	0.4872
1.11 – 1.20	1.155	2	2.310	200	0.7980	0.6368
Σ		200	71.400			2.1673
Mean trace length (X) = $\frac{\Sigma fx}{\Sigma f} = \frac{71.400}{200}$						0.3570m

Table 4 Trace Length Classification Table for RCF Quarry

Class Interval (Trace length)	Class mark(x)	Frequency (f)	Fx	Cumulative Frequency	x - X	$(x-X)^2$
0.01 – 0.25	0.13	60	7.80	90	-0.8719	0.7602
0.26 – 0.50	0.38	48	18.24	108	-0.6219	0.3867
0.51 – 0.75	0.63	26	16.38	134	-0.3719	0.1383
0.76 – 1.00	0.88	8	7.04	142	-0.1219	0.0148
1.01 – 1.25	1.13	4	4.52	146	0.1281	0.0164
1.26 – 1.50	1.38	5	6.90	151	0.3781	0.1429
1.51 – 1.75	3.26	3	9.78	154	2.2581	5.0990
1.76 – 2.00	1.88	3	5.64	157	0.8781	0.7710
2.01 – 2.25	2.13	6	12.78	163	1.1281	1.2726
2.26 – 2.50	2.38	6	14.28	169	1.3781	1.8991
2.51 – 2.75	2.63	4	10.52	173	1.6281	2.6507
2.76 – 3.00	2.88	10	28.80	183	1.8781	3.5272
3.01 – 3.25	3.13	6	18.78	189	2.1281	4.5288
3.26 – 3.50	3.38	5	16.90	194	2.3781	5.6553
3.51 – 3.75	3.63	4	14.52	198	2.6281	6.9069
3.76 – 4.00	3.88	2	7.76	200	2.8781	8.2834
Σ		200	200.37			42.0533
Mean trace length (X) = $\frac{\Sigma fx}{\Sigma f} = \frac{200.37}{200}$						1.0019m

Table 4 shows that the most frequent value of the outcrop persistence is 60 and the mean trace length was 1.0019m which indicates that the rock mass have low persistence and falls within 1m - 3m of [1] Discontinuity Spacing Classification Table. Hence, the rock mass have a relatively small block size. The result indicated that with low discontinuities persistence, good blast performance will be achieved.

Table 5 shows the uniaxial compressive strength of the rock samples. The uniaxial compressive strength of the rock samples varies from 150.930 MPa to 153.160 MPa as with a mean value of 152.320 MPa point load index which indicates that the result lies within 70 MPa to 180 MPa of [14] Uniaxial Compressive Strength Classification Table. Also, Table 6 shows the point load strength of the rock sample. The maximum load varies from 45.300 kN to 45.800 kN as diameter of the rock samples remains unchanged. The maximum load varies as a result of the rock formations and compositions there by causing the point load strength to vary with a mean value of 13.732 MPa point load index that lies within 7 MPa to 15MPa of [14] Corrected Point Load Is(50)) Classification. Therefore with these high uniaxial compressive strengths and point load strength, high explosives with high powder factor will be required for good fragmentation.

Table 5 Uniaxial Compressive Strength for RCF Quarry

Length (M)	Area (M^2)	Maximum load, P (N)	Uniaxial Compressive Strength (MPa)	Mean Value of Uniaxial Compressive (MPa)
0.05	0.0025	382.175	152.870	
0.05	0.0025	377.325	150.930	152.320
0.05	0.0025	382.400	153.160	

Table 6 Point Load Strength for RCF Quarry

De (M)	De^2 (M^2)	F	P (kN)	$Is_{(un)}$ (MPa)	$Is_{(50)}$ (MPa)	Mean Value of Point Load (MPa)
0.06	0.0036	1.085	45.800	12.722	13.803	
0.06	0.0036	1.085	45.300	12.583	13.652	13.732
0.06	0.0036	1.085	45.600	12.666	13.743	

Table 7 Summary of Dip Angle Classification for Kopek Quarry

Class Interval (Dip Angle) in Degree	Frequency(f)	Cumulative Frequency
1 – 10	20	20
11 – 20	15	35
21 – 30	24	59
31 – 40	05	64
41 – 50	10	74
51 – 60	15	89
61 – 70	10	99

Table 8 Summary of Total Spacing Classification Table for Kopek Quarry

Class Interval (Total Spacing)	Class mark(x)	Frequency(f)	Fx	Cumulative Frequency	x - X	$(x–X)^2$
0.01 – 0.10	0.055	30	1.650	30	-0.2828	0.0799
0.11 – 0.20	0.155	18	2.790	48	-0.1828	0.0334
0.21 – 0.30	0.255	4	1.020	52	-0.0828	0.0068
0.31 – 0.40	0.355	12	4.260	64	-0.0172	0.0002
0.41 – 0.50	0.455	10	4.550	74	0.1172	0.0137
0.51 – 0.60	0.555	3	1.665	77	0.2172	0.0471
0.61 – 0.70	0.655	10	6.550	87	0.3172	0.1006
0.71 – 0.80	0.755	4	3.020	91	0.4172	0.1740
0.81 – 0.90	0.855	2	1.710	93	0.5172	0.2674
0.91 – 1.00	0.955	3	2.865	96	0.6172	0.3809
1.01 – 1.10	1.055	1	1.055	97	0.7172	0.5143
1.11 – 1.20	1.155	2	2.310	99	0.8172	0.6678
Σ		99	33.445			2.2861
Mean Spacing (X) = $\frac{\Sigma fx}{\Sigma f} = \frac{33.445}{99}$						0.3378m

3.2 Kopek Quarry

Table 7 shows the dip angle data classification and they were grouped with class interval of 100. It was shown that the most frequent value of the outcrop dip angle was 24 and falls between the modal class 210 – 300 of 99 discontinuity measurements.

Table 8 shows the total spacing data classification and they were grouped with class interval of 0.1m. It was shown that the most frequent value of the outcrop totals spacing was 30 and lies between the modal class 0.01m - 0.10m. The total discontinuity spacing distributions of the outcrop was nearly evenly spaced. The mean spacing of the outcrop was 0.3378m (337.8 mm) which indicates the outcrop was moderately spaced and falls within 200 mm - 600 mm of [1] Discontinuity Spacing Classification Table. With moderately spaced discontinuities, good blast performance will be achieved. The rock masses are less susceptible to infill with materials and water, therefore strength reduction and weathering through these processes are rarely uncommon.

Table 9 shows that the most frequent value of the outcrop persistence was 18 and mean trace length was 1.4205m which indicates that the rock mass have low persistence and falls within 1m - 3m of [1] Discontinuity Spacing Classification Table. Hence, the rock mass have a relatively small block size. The result indicated that with low discontinuities persistence, good blast performance will be achieved.

Table 10 shows the uniaxial compressive strength. The uniaxial compressive strength of the rock samples varies from 131.248 MPa to 133.440 MPa and the mean value of uniaxial compressive strength was 132.256 MPa which indicates that the result lies within 70 MPa to 180 MPa of [13] Uniaxial Compressive Strength Classification Table. Also, Table 11 shows the point load strength of the rock sample. The maximum load varies from 31.200 kN to 32.900 kN as diameter of the rock samples remains constant. The maximum load varies as a result of the rock formations and compositions thereby causing the point load strength to vary with a mean value of 9.713 MPa that lies within 7MPa to 15MPa of [14] Corrected Point Load (Is(50)) Classification. Therefore with these high uniaxial compressive strengths and point load strength, high explosives with high powder factor will be required for good fragmentation.

3.3 Samchase Quarry

Table 12 shows the dip angle data classification and they were grouped with class interval of 100. It was shown that the most frequent value of the outcrop dip angle was 65 and falls between the modal class 510 – 600 of 303 discontinuity measurements.

Table 9 Summary of Trace Length Classification Table for Kopek Quarry

Class Interval (Trace length)	Class mark(x)	Frequency(f)	Fx	Cumulative Frequency	x - X	$(x-X)^2$
0.01 – 0.25	0.13	18	2.34	18	-1.2905	1.6653
0.26 – 0.50	0.38	12	4.56	30	-1.0405	1.0826
0.51 – 0.75	0.63	10	6.30	40	-0.7905	0.6248
0.76 – 1.00	0.88	10	8.80	50	-0.5405	0.2921
1.01 – 1.25	1.13	8	9.04	58	-0.2905	0.0843
1.26 – 1.50	1.38	6	8.28	64	-0.0405	0.0016
1.51 – 1.75	3.26	2	6.52	66	1.8395	3.3837
1.76 – 2.00	1.88	3	5.64	69	0.4595	0.2111
2.01 – 2.25	2.13	6	12.78	75	0.7095	0.5033
2.26 – 2.50	2.38	2	4.76	77	0.9595	0.9206
2.51 – 2.75	2.63	4	10.52	81	1.2095	1.4628
2.76 – 3.00	2.88	4	11.52	85	1.4595	2.1301
3.01 – 3.25	3.13	3	9.39	88	1.7095	2.9223
3.26 – 3.50	3.38	3	10.14	91	1.9595	3.8396
3.51 – 3.75	3.63	4	14.52	95	2.2095	4.8818
3.76 – 4.00	3.88	4	15.52	99	2.4595	6.0491
Σ		99	140.63			30.0551
Mean trace length (X) = $\frac{\Sigma fx}{\Sigma f} = \frac{140.63}{99}$						1.4205m

Table 10 Uniaxial Compressive Strength for Kopek Quarry

Length (M)	Area (M^2)	Maximum load, P (N)	Uniaxial Compressive Strength (MPa)	Mean Value of Uniaxial Compressive (MPa)
0.05	0.0025	328.120	131.248	
0.05	0.0025	333.600	133.440	132.256
0.05	0.0025	330.200	132.080	

Table 11 Point Load Strength for Kopek Quarry

De (M)	De^2 (M^2)	F	P (kN)	$Is_{(un)}$ (MPa)	$Is_{(50)}$ (MPa)	Mean Value of Point Load (MPa)
0.06	0.0036	1.085	32.900	9.138	9.914	
0.06	0.0036	1.085	31.200	8.666	9.402	9.713
0.06	0.0036	1.085	32.600	9.055	9.824	

Table 12 Dip Angle Classification for Samchase Quarry

Class Interval (Dip Angle) in Degree	Frequency(f)	Cumulative Frequency
1 – 10	10	0
11 – 20	35	45
21 – 30	41	86
31 – 40	54	140
41 – 50	35	175
51 – 60	65	240
61 – 70	20	260
71 – 80	15	278

81 – 90	28	303

Table 13 Total Spacing Classification Table for Samchase Quarry

Class Interval (Total Spacing)	Class mark(x)	Frequency (f)	Fx	Cumulative Frequency	x - X	$(x–X)^2$
0.01 – 0.10	0.055	68	3.74	68	-0.2884	0.0832
0.11 – 0.20	0.155	55	8.525	123	-0.1884	0.0354
0.21 – 0.30	0.255	47	11.985	170	-0.0884	0.0078
0.31 – 0.40	0.355	24	8.52	194	0.0116	0.0001
0.41 – 0.50	0.455	30	13.65	224	0.1116	0.0125
0.51 – 0.60	0.555	24	13.32	248	0.2116	0.0447
0.61 – 0.70	0.655	18	11.79	266	0.3116	0.0971
0.71 – 0.80	0.755	14	10.57	280	0.3210	0.1030
0.81 – 0.90	0.855	10	8.55	290	0.5116	0.2617
0.91 – 1.00	0.955	7	6.685	297	0.6116	0.3741
1.01 – 1.10	1.055	4	4.22	301	0.7116	0.5064
1.11 – 1.20	1.155	2	2.31	303	0.8116	0.6587
Σ		303	104.045			2.1847
Mean Spacing (X) = Σfx / Σf = 104.045 / 303						0.3434m

Table 14 Trace Length Classification Table for Samchase Quarry

Class Interval (Trace length)	Class mark(x)	Frequency (f)	Fx	Cumulative Frequency	x - X	$(x-X)^2$
0.01 – 0.25	0.13	80	10.4	80	-0.8903	0.7926
0.26 – 0.50	0.38	62	23.56	142	-0.6403	0.4099
0.51 – 0.75	0.63	42	26.46	184	-0.3903	0.1523
0.76 – 1.00	0.88	20	17.6	204	-0.1403	0.0196
1.01 – 1.25	1.13	12	13.56	216	0.1097	0.0168
1.26 – 1.50	1.38	18	24.84	234	0.3597	0.1293
1.51 – 1.75	3.26	4	13.04	238	2.2397	5.0162
1.76 – 2.00	1.88	5	9.4	243	0.8597	0.7390
2.01 – 2.25	2.13	9	19.17	252	1.1097	1.2314
2.26 – 2.50	2.38	9	21.42	261	1.3597	1.8487
2.51 – 2.75	2.63	8	21.04	269	1.6097	2.5911
2.76 – 3.00	2.88	11	31.68	280	1.8597	3.4584
3.01 – 3.25	3.13	11	34.43	291	2.1097	4.4508
3.26 – 3.50	3.38	6	20.28	297	2.3597	5.5681
3.51 – 3.75	3.63	4	14.52	301	2.6097	6.8105
3.76 – 4.00	3.88	2	7.76	303	2.8597	8.1778
Σ		303	309.16			41.4125
Mean trace length (X) = Σfx / Σf = 309.16 / 303						1.0203m

Table 15 Uniaxial Compressive Strength for Samchase Quarry

Length (M)	Area (M^2)	Maximum Load, P (N)	Uniaxial Compressive Strength (MPa)	Mean Value of Uniaxial Compressive (MPa)
0.05	0.0025	300.100	120.040	
0.05	0.0025	305.500	122.200	120.973

0.05	0.0025	301.700	120.680

Table 15 Point load Strength for Samchase Quarry

De (M)	De^2 (M^2)	F	P (kN)	$Is_{(un)}$ (MPa)	$Is_{(50)}$ (MPa)	Mean Value of Point Load (MPa)
0.06	0.0036	1.085	39.600	11.000	11.935	
0.06	0.0036	1.085	39.900	11.083	12.025	11.953
0.06	0.0036	1.085	39.400	10.944	11.874	

Table 13 shows the total spacing data classification and they were grouped with class interval of 0.1m. It was shown that the most frequent value of the outcrop total spacing was 68 and lies between the modal class 0.01m - 0.10m. The total discontinuity spacing distributions of the outcrop was not evenly spaced. Mean spacing of the outcrop was 0.3434m (343.4 mm) which means the outcrop was moderately spaced and falls within 200 mm – 600 mm of [1] Discontinuity Spacing Classification Table. With moderately spaced discontinuities, good blast performance will be achieved. The rock masses are less susceptible to infill with materials and water, therefore strength reduction and weathering through these processes are uncommon.

Table 14 shows that the most frequent value of the outcrop persistence was 68 and the mean trace length was 1.0203m which indicates that the rock mass have low persistence and falls within 1m-3m of [1] Discontinuity Spacing Classification Table. Hence, the rock mass have a relatively small block size. The result indicated that with low discontinuities persistence, good blast performance will be achieved.

Table 15 shows the uniaxial compressive strength. The uniaxial compressive strength of the rock samples varies from 120.040 MPa to 122.200 MPa and the mean value of uniaxial compressive strength was 120.973 MPa which indicates that the result lies within 70 MPa to 180 MPa of [13] Uniaxial Compressive Strength Classification Table. Also, Table 15 shows the point load strength of the rock sample. The maximum load varies from 39.400 kN to 39.900 kN as diameter of the rock samples remains constant. The maximum load varies as a result of the rock formations and compositions thereby causing the point load strength to vary with a mean value of 11.953 MPa that lies within 7MPa to 15MPa of [14] Corrected Point Load (Is(50)) Classification. Therefore with these high uniaxial compressive strengths and point load strength, high explosives with high powder factor will be required for good fragmentation.

4. Conclusion

The quantitative and qualitative measurements were carried out to determine blasting performance of rocks in the selected quarries. The analysis shows that rocks spacing are moderately spaced, rock mass has low persistence (1.0019m for RCF, 1.4205m for Kopek and 1.0203m for Samchase quarry) and the rock mass block size are relatively small. With moderately spaced, low persistence and high strengths outcrops, various blast performances were achieved. The study therefore concluded that in any discontinuous rock, it is more advantageous to analyze rock discontinuities, determine uniaxial compressive strengths and point load strengths before blasting takes place and recommended that benches should be opened at an angle 200 for higher safety since the rocks occurred as extrusive formations; with no or little overburden.

References

[1] ISRM (1978). Suggested Methods for Quantitative Description of Discontinuities in Rock Masses. International Society of Rock Mechanics, Commission on Standardization of Laboratory and Field Tests, International Journal of Rock Mechanics, Mineral Science and Geomechanics Abstract 15, pp. 319-368.

[2] Beally, F.G. (2010). Engineering Properties of Soils and Rocks 10th Edition, Butterworth-Heineman Ltd, Oxford, pp. 56-78.

[3] Stephen J.T. (2012). Rock Mass Strength Parameters Evaluation, Statistics, 13th Edition Dellen Publishing Company, Singapore, pp. 7-45.

[4] Frenket A.J. and Fairfield K.B. (2003). Rock Engineering, McGraw Hill Books, Second Edition, Singapore, pp. 78-90.

[5] Lally and Wanes (2001). Introduction to Rock Mechanics, Second Edition, John Wiley and Sons U.S.A, pp. 14-219.

[6] Price D.A. and Hudson J. (2003). Estimation of Discontinuity Spacing and Trace Length using Scan Line Surveys. International Journal of Rock

Mechanics, Mineral Science and Geomechanics Abstract, 18, pp. 13-198.

[7] Hustrulid W. (2007). Blasting Principles for Open Pit Mining. Vol. I. A.A. Balkema,

Rotterdam, pp. 27- 31, 854-875.

[8].Priest S. D. (2007). Estimation of Discontinuity Spacing and Trace Length Using

Scaline Surveys. Int J. Rock Mech Min Sci and Geomech. Abstr, 18, pp. 13-198, 24-216.

[9] Prince C. K. (2009). Introduction of Discontinuity Parameters in Rock Mass, McGraw

Hill, New York, pp. 10-104.

[10].Zhang L and Einstein H.H. (2000). Estimating

Persistence of Rock Discontinuities. International Journal of Rock Mechanics and Mineral Science. 37(5), pp 817-837.

[11].Trust Well and Cope (2006). Introduction to Origin of Rock Types, Lulea. pp 55-112.

[12] Dalay B. N. (2007). Introduction to Specific Gravity Classifications Rock Types, United

State of America, pp. 27-35.

[13] ISRM (1981). Rock Characterization, Testing and Monitoring. ISRM Suggested Methods. ln: Brown, E.T. (ed). Commission on Testing Methods, International Society for Rock Mechanics (ISRM), Pergamon Press, Oxford, UK. pp 113-114.

[14] ISRM (1985). Suggested Method for Determining Point Load Strength. Commission on Testing Methods. Working Group on Revision of the Point Load Test Method, Int. Journal Rock Mech. Min. Sc. Vol.22, No.2, pp. 51-60.