CORRELATIONS BETWEEN UNIAXIAL COMPRESSIVE STRENGTH AND POINT LOAD STRENGTH FOR SOME BRAZILIAN HIGH-GRADE METAMORPHIC ROCKS

TENTATIVAS DE CORRELAÇÕES ENTRE RESISTÊNCIA À COMPRESSÃO UNIAXIAL E RESISTÊNCIA À COMPRESSÃO PUNTIFORME PARA ALGUMAS ROCHAS METAMÓRFICAS DE ALTO GRAU DO BRASIL

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RESUMO

Esse artigo apresenta os resultados de um estudo laboratorial detalhado com o objetivo de determinar a resistência uniaxial e puntiforme de rochas metamórficas de alto grau, assim como avaliar a relação altura/diâmetro (H/D) sobre a resistência à compressão uniaxial de rochas com razões H/D entre 2,0 e 2,5 e entre 2,5 e 3,0. Todos os ensaios foram realizados com base nas sugestões da ISRM (2007) em quatro litotipos metamórficos de alto grau diferentes, comumente encontrados no Quadrilátero Ferrífero. Os ensaios de laboratório realizados foram resistência à compressão uniaxial e puntiforme e ensaios de caracterização física (peso específico aparente seco e saturado, porosidade aparente e capacidade de absorção de água). Os coeficientes de correlação foram determinados para cada tipo de rocha. Os resultados da análise da variação da relação H/D mostram que, para as rochas em estudo, a utilização de ensaios com relação entre 2.0 e 2.5 não mostram diferenças significativas para aquelas realizadas com relação entre 2.5 e 3.0

ABSTRACT

This paper presents the results of a comprehensive laboratory study with the aim of determination of both uniaxial and point load strength, and its relationship for some metamorphic rocks, as long as long as an evaluation of highness/diameter ratio (H/D ratio) over uniaxial compressive strength, throughout testing samples with H/D ratio between 2.0 to 2.5 and from 2.5 to 3.0. All tests were done according to ISRM (2007) for four different high-grade metamorphic lithotypes commonly found at the south of Iron Quadrangle, Minas Gerais state, Southeast Brazil. Test program comprises uniaxial compressive strength, point load and physical characterization tests (dry specific weight, saturated specific weight, porosity and water absorption capacity). Correlation coefficients were then determinate for strength tests for each rock type. H/D ratio results show that, for rock under study, use of rock samples with H/D ratio between 2.0 and 2.5 do not show significance differences from those carried out with the H/D ratio suggested by ISRM methods.

Keywords: strength correlation; uniaxial compressive strength; point load tests; H/D ratio, metamorphic rocks.

1 INTRODUCTION

Rocks are solid consolidated materials, naturally formed by mineral material aggregates, which are, together with discontinuities – fractures, faults, foliation etc., fundamental components of rock masses (Azevedo & Marques, 2006). Among several properties frequently used to characterize rocks, density, deformability, permeability and strength are the most common in problems involving slope stability and excavations problems. These properties can be measured in situ or throughout lab tests, which can provide rock/rock mass quality indication.

According to Bieniawski (1989), the importance of intact rock properties for the general rock mass behavior will be generally supplanted by the discontinuities behavior. However, this does not mean that intact rock properties should not be considered. After all, if the discontinuities are highly spaced or if the intact rock is fragile or weathered, its properties can strongly influence the geomechanical behavior of rock mass (Azevedo & Marques 2006).

In this context, studies involving geomechanical and physical characterization of both intact rock and discontinuities - as a way of providing a rock quality index; which can, in addition to empirical methods, relate factors that can influence the behavior of rock masses and provide a rock mass classification, dividing the mass into equal behavior zones.

Rocks on rock masses are in general subjected to triaxial confinement. But, on rock slope cuts or underground mining pillar, uniaxial stress state represents most appropriate the stress state and has been the most used properties on such projects.

Thus, uniaxial compressive strength tests as long as point load tests – this last one with the great advantage of easiness of tests on irregular rock samples, have been commonly used on rock characterization on several civil and mining engineering problems.

The relationship between uniaxial compressive strength (UCS) and point load strength (PLS), called the strength conversion factor (k), has been used to estimate the UCS from the PLS since the 1960s. Many researchers have investigated the relationship between UCS and PLS for various rock types, such as igneous, sedimentary, and metamorphic rocks, also the common k value is within the range 20-25 for a standard-size (50 mm) core (Broch & Franklin 1972, Bieniawski 1975, Greminger 1982, ISRM 1985; Singh & Singh 1993, Kaya & Karaman 2015). However, Karaman et al. (2015) obtained the strength conversion factors equal 18.2, 16.6 and 18.2 for igneous, metamorphic and sedimentary rocks, respectively. Moreover, some researchers have used the regression method to elucidate linear relationships between UCS and PLS (D'Andrea et al. 1964, Deere & Miller 1966, Gunsallus & Kulhawy 1984, O'Rourke 1989; Cargill & Shakoor 1990, Karaman 2001, Fener et al. 2005, Cobanoglu & Celik 2008, Basu & Kamran 2010). Azimian et al. (2014) and Kilic & Teymen (2008) obtained a strong logarithmic relationship between UCS and PLS for weathered rocks and different rock types. Finally, Read et al. (1980) showed that the UCS/PLS ratio varies with both rock type and weathering grade.

Another important aspect related to UCS tests is the influence of the highness – diameter (H/D) ratio on UCS values. This effect is well known (Thuro et al. 2001) but every few studies has been published on more recent years on this issue, but one can be cite Hoek & Brown (1980), Hamkins (1998), Hong et al. (2008) and You & Su (2004). Thuro et al. (2001), studying three different rock types (mafic dikes, granite and limestone) have conclude that this ratio has low effect over rock strength when compared, for example, with the shape of rock samples.

In this context the present study has the aim of characterization of UCS and PLS for 4 (four) lithotypes occurring in an area located at the south of the Iron Quadrangle, Minas Gerais state; contributing to the definition of practical correlations among these two properties for the rocks under study. Also, UCS rock samples were produced on two different H/D ratios, 2,0 to 2,5 and 2,5 to 3,0, in order to evaluate its influence over these rocks strength.

2 MATERIALS AND METHODS

In order to carry on the proposed study, the following lab tests were done:

- Uniaxial compressive strength tests on cylinder samples;
- Point load strength tests on cylinder and blocky (irregular) samples;
- Dry sand saturated specific density;
- Apparent porosity; and
- Water absorption capacity.

Every test was done according to the ISRM (2007) on Rock Mechanics Laboratory of Civil Engineering Department of Universidade Federal de Viçosa.

2.1 Tested Materials

The study was executed on four different rock types – metamorphosed granite – here named granite NE (GNE), graphite rich schist (XG), quartz biotite schist (QBX) and silica rich carbonated rock, all highly metamorphic (Figure 1).

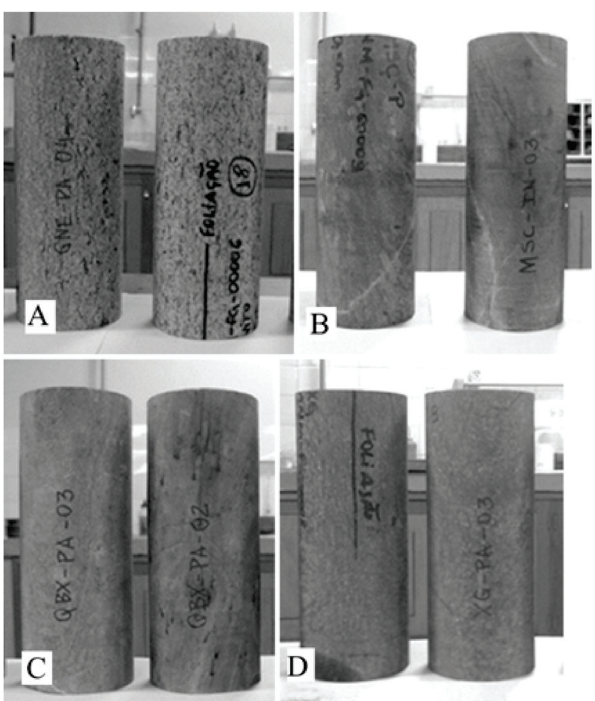

Figure 1 – Tested lithotypes (a) Granite NE; (b) Silica rich carbonated rock; (c) Quartz Biotite Schist and (d) Graphite rich Schist.

Rock testing samples were prepared from rock drilling samples – for UCS and axial PLT strength tests, samples cut from rock blocks (block PLT tests) and irregular samples for PLT tests. Rocks tested and its weathering grades are presented on Table 1.

Table 1 - Weathering grades for rocks samples tested.

Rocks Id	Abbreviation	Weathering Grade
Granite NE	GNE	W_2/W_1
Silica rich carbonated rock	MSC	W_2/W_1
Quartz Biotite Schist	QBX	W_2/W_3
Graphite rich Schist	XG	W_3

Test samples were considered inclined (IN) to loading axis when they present foliation at an angle higher than 10º to the samples axis, as illustrated on Figure2a. Samples with foliation at angles lower the 10º to the sample axis were considered parallel (PA). Finally, samples with angle between 70º e 90º to the sample axis were considered perpendicular (PE). Rock samples for which were not possible to identify foliation (Figure2b) were considered isotropic.

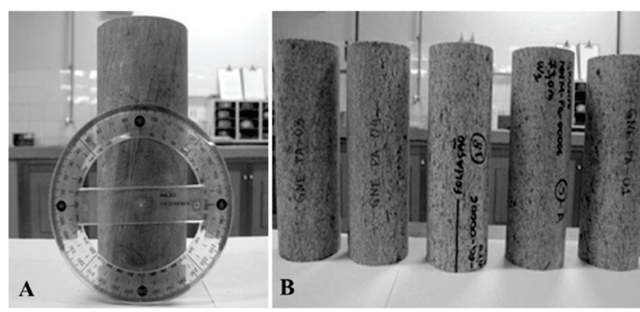

Figure 2 – Inclination of rock samples tested.

2.2 Physical Indexes

For the determination of physical indexes tests were done using buoyancy technique, which allows the determination of porosity and density on irregular as well as on regular samples.

For test procedures representative rock samples were prepared and composed by 10 rock fragments with a minimum mass of 50 g for each one of the lithotypes under study.

2.3 Uniaxial Compression

The method used for determination of uniaxial compressive strength allows the use of core samples obtained from boreholes (cylinders). The height to diameter ratio (H/D ratio) to be used on rock samples for uniaxial compressive strength tests is a matter already under discussion. ISRM

(2007) recommends the use of samples H/D ratio between 2.5 and 3.0, while American standards ASTM (2013) suggests H/D ratio 2.5 and 2.5. Finally Eurocode 7 (2007) allows the use of rock samples with H/D ratio between 2 to 3.

Boreholes cylinder samples from which uniaxial and point load tests samples were extracted had a diameter equal to 67.0 ± 0.5 mm. So, to obey ISRM´s standards uniaxial compressive test rock samples were produced with a height of 17.0 ± 0.5 cm, in order to be compared with point load tests results. Samples were prepared on a diamond saw and both ends were flattened in order to reduce waviness and to maintain its perpendicularity to the sides of the specimen.

Two groups of samples to be tested on uniaxial compressive testes were produced, the first with H/D ratio between 2.0 and 2.5, and the second one with H/D ratio 2.5 to 3.0, as shown on Figure 3.

The representativeness of tests was guaranteed by the application of a continuous and constant loading, in order to provide the failure of rock sample between 5 to 10 min and as well as by the number of tested samples, varying form a minimum of 3 and maximum of 5 samples. Tests were developed in a 100 tons hydraulic machine. Values of uniaxial compressive strength (q_u), in MPa, were calculated through equation (1).

$$q_u = P/A \tag{1}$$

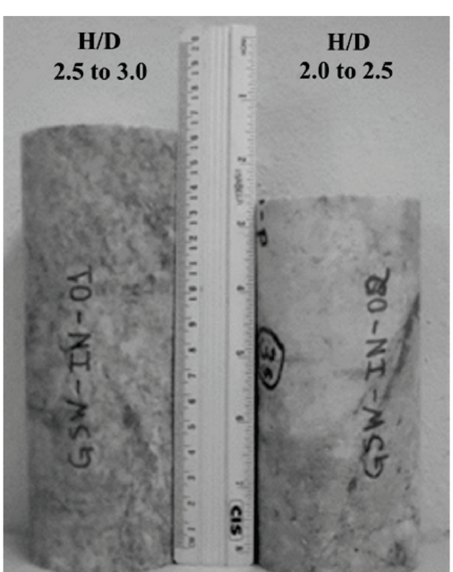

Figure 3 – Example of uniaxial compressive strength rock test samples with two different H/D ratios.

2.3.1 Effects of Different H/D Ratio on Uniaxial Compressive Strength

Hoek and Brown (1980), based on observations of a series of uniaxial tests, have proposed that uniaxial compressive strength should be normalized by dividing individual strength of each sample to the strength of a sample with a diameter of 50 mm. The proposed correction is determined throughout Equation. (2).

$$\sigma_c = \sigma_{c50}\left(\frac{50}{d}\right)^{0,18} \tag{2}$$

On the present study the correction proposed by those authors was used on both H/D ratio samples tested.

2.4 Point Load Test

According to the method proposed by Broch & Franklin (1972), point load irregular tests samples were prepared with 50 mm ± 35 mm and W/D ratio between 0.3 and 1.0 (preferably close to 1.0); and L value of at least 0.5 W. For cylinder samples, dimensions were prepared with a W/D ratio between 0.3 and 1.0 for axial load tests. Figure 4 shows the dimensions suggested by ISRM (2007) and used on the present study.

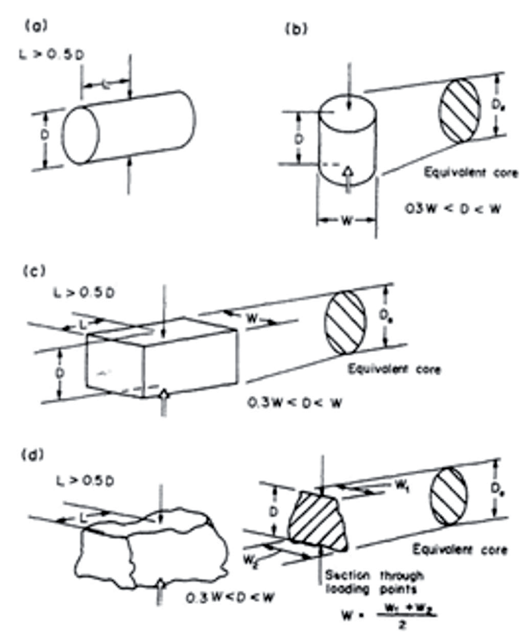

Figure 4 – Rock samples dimensions for point load tests (ISRM 2007).

To guarantee the representativeness of tests, loading was applied constantly in such a way that failure occurs between 10 to 60 seconds. Results were considered not valid when failure surface pass throughout only one of the loading points (Figure 5). A Controls® equipment, model D550, was used for testing.

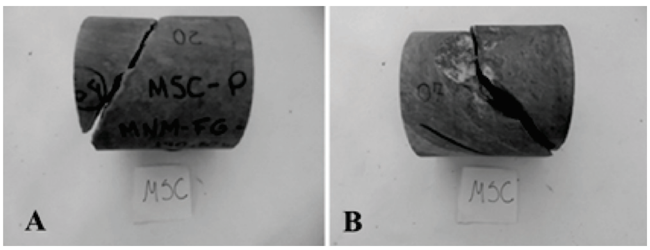

Figure 5 – Example of point load test results considered not valid (a) and valid (b).

On those point load tests were 10 or more samples were tested, the two highest and the two lowest load failure values were not considered for the calculus of the average point load strength index. As suggested by ISRM (2007), the minimum value of point load test results to be considered for this calculus should never be inferior to six.

2.5 Correlation Between Uniaxial Compressive and Point Load Strength

Point load strength index $IS_{(50)}$ is defined for the test carried out on cylinder rock samples for a standardized diameter equal to 50 mm. Tests carried out on different diameter samples must be corrected to definition of $IS_{(50)}$. Therefore, it is necessary to calculate the value of point load strength (Is) and multiply by a Correction Factor (CF), which is a function of a relation between sample diameter (D) and the 50 mm standardized diameter, according to equations. (3) to (5).

$$I_S = \frac{P}{D^2} \tag{3}$$

$$I_{S(50)} = FC.\frac{P}{{D_e}^2} \tag{4}$$

$$FC = \left(\frac{D_e}{50}\right)^{0,45} \tag{5}$$

Where:
D and D_e are given in mm.
D_e – equivalent diameter of each tested sample, given by:
$D_e^2 = D^2$ – for diametral tests; and
$D_e^2 = 4\,A/\pi$ – for axial tests or irregular samples, in which $A = WD$.

For irregular and cylinder samples submitted to axial loading it is necessary to define an equivalent diameter, D_e, to obtain a value corresponding to standardized test (see Figure 3).

The final point load test result is commonly correlated to uniaxial compressive strength, q_u, throughout the linear relationship on Equation (6).

$$q_u = K.I_{S(50)} \tag{6}$$

Goodman (1989) presents a conversion factor, K, equal to 24. For Barroso (1993) this factor varies from 18 to 24, while for Foster (1983), K can vary from 10 to 50, as most of the estimates found in literature. And, others researchers present different values as presented earlier.

3 RESULTS

On the following sections the main results obtained on this study are presented.

3.1 Physical Indexes

On Table 2 values of dry and saturated specific weight, apparent porosity and water absorption capacity are presented for each lithotype under study.

Table 2 - Results of physical indexes, for each lithotype.

Lithotype	Specific Weight (kg/m³)		Apparent porosity (%)	Water absorption capacity (%)
	Dry	Saturated		
GNE	2643	2651	0.76	0.29
MSC	3520	3527	0.68	0.19
QBX	2753	2780	2.35	0.85
XG	2841	2850	0.82	0.29

3.2 Uniaxial Compressive Strength

After determination of the cross section area (A) and load at failure (P) for each rock sample tested, uniaxial strength was been calculated and the results are presented on Table 3 and Table 4, for H/D ratio between 2.0 and 2.5; and for 2.5 and 3.0, respectively. Besides calculated compressive strength (σc), also corrected tensions (σc(50)) were determined, as presented on section 2.3.1.

Table 3 - Uniaxial compressive strength for samples with H/D ratio between 2.0 and 2.5.

Lithotype	Sample	H/D	A (cm²)	P (kg)	σ_c (MPa)	$\sigma_{c(50)}$ (MPa)
GNE	GNE-PA 1	2.16	35.26	63000	175.12	166.13
	GNE-PA 2	2.16	35.26	56860	158.05	149.94
	GNE-PA 3	2.14	34.89	67650	190.02	180.44
	GNE-PA 4	2.15	35.05	54580	152.62	144.87
	GNE-PA 5	2.06	35.20	48640	135.40	128.47
MSC	MSC-IN 1	2.15	34.89	85990	241.54	229.36
	MSC-IN 2	2.15	35.26	73400	204.02	193.55
	MSC-IN 3	2.06	35.26	50360	139.98	132.80
	MSC-IN 4	2.03	35.47	75630	208.97	198.14
	MSC-IN 5*	2.16	35.26	21000	58.37	55.37
QBX	QBX-IN 1	2.18	35.10	16770	46.82	44.44
	QBX-IN 2	2.13	35.41	11230	31.08	29.47
	QBX-IN 3	2.14	35.10	9810	27.39	25.99
	QBX-IN 4	2.13	35.26	10850	30.16	28.61
XG	XG-IN 1	2,17	34.73	25870	72.99	69.34
	XG-IN 2	2.17	35.26	17730	49.28	46.75
	XG-IN 3	2.17	35.26	12400	34.47	32.70
	XG-IN 4	2.17	35,20	28610	76.64	72.72

*Fractured sample. Result not considered.

Table 4 - Uniaxial compressive strength for samples with H/D ratio between 2.5 and 3.0.

Lithotype	Sample	H/D	A (cm^2)	P (kg)	σ_c (MPa)	$\sigma_{c(50)}$(MPa)
GNE	GNE-PA 1	2.57	34.99	65320	182.93	173.66
	GNE-PA 2	2.60	34.84	69440	195.34	185.52
	GNE-PA 3	2.57	35.26	65760	182.79	173.41
	GNE-PA 4	2.55	35.26	67550	187.76	178.13
	GNE-PA 5	2.57	35.10	52060	145.36	137.95
MSC	MSC-IN 1	2.55	35.26	34000	94.51*	89.66
	MSC-IN 2	2.53	35.47	87990	243.13	230.53
	MSC-IN 3	2.56	35.26	66990	186.21	176.65
	MSC-IN 4	2.53	35.26	62451	173.59	164.68
QBX	QBX-PA 1	2.55	35.10	4980	13.90	13.19
	QBX-PA 2	2.53	35.15	5880	16.39	15.55
	QBX-PA 3	2.56	35.26	7190	19.99	18.96
	QBX-PA 4	2.57	34.94	10190	28.58	27.14
	QBX-PA 5	2.58	35.26	9680	26.91	25.53
QBX	QBX-IN 1	2.61	33.05	10380	29.03	27.55
	QBX-IN 2	2.60	34.78	14400	38.53	35.53
	QBX-IN 3	2.59	35.20	15880	44.21	41.94
	QBX-IN 4	2.58	34.94	36580	97.41*	97.41
XG	XG-PA 1	2.55	35.26	17250	47.95	45.49
	XG-PA 2	2.57	34.73	36220	102.2*	97.08
	XG-PA 3	2.56	35.31	14820	41.13	39.02
	XG-PA 4	2.56	35.26	15650	43.5	41.27
	XG-PA 5	2.58	34.94	36600	102.65*	97.46

*Result not considered.

For uniaxial compressive strength with no correction for a 50mm size, average values were then determined, and results are presented on Table 5. Results that have shown high discrepancies or those for which failure has occurred out of the 5 to 10min gap were not considered for the average calculus.

Table 5 - Uniaxial compressive strength average values for samples with H/D ratio between 2.0 and 3.0

Lithotype	average (H/D = 2.5 e 2.5)	average (H/D = 2.5 e 3.0)
GNE	162.24 MPa ± 21.02 MPa	178.84 MPa ± 19.40 MPa
MSC	198.63 MPa ± 42.49 MPa	200.97 MPa ± 37.05 MPa
QBX	33.86 MPa ± 8.78 MPa	37.93 MPa ± 7.93 MPa
XG	58.35 MPa ± 20.01 MPa	41.97 MPa ± 3.46 MPa

3.3 Point Load Strength

For point load test, the standard strength average value for each lithotype was calculated. On Table 6 to Table 9 results are presented for cylinder samples for each rock type under study.

Table 6 - Point load test results for cylinder granite samples.

Sample Number	Granite						
N	P (kN)	De² (mm²)	De (mm)	Is (MPa)	FC	$Is_{(50)}$ (MPa)	Not Considered
1	19.40	2968.69	54.49	6.53	1.04	6.79	X
2	17.80	3036.93	55.11	5.86	1.04	6.12	
3	21.40	3057.30	55.29	7.00	1.05	7.32	
4	18.50	2908.56	53.93	6.36	1.03	6.58	
5	21.50	3236.83	56.89	6.64	1.06	7.04	
6	19.50	2934.56	54.17	6.64	1.04	6.89	
7	23.00	3040.92	55.14	7.56	1.05	7.90	X
8	15.50	3027.87	55.03	5.12	1.04	5.34	
9	17.30	2985.75	54.64	5.79	1.04	6.03	
10	14.00	2891.78	53.78	4.84	1.03	5.00	X

Table 7 - Point load test results for cylinder Silica rich carbonated samples.

Sample Number	Silica rich carbonated rock						
N	P (kN)	De² (mm²)	De (mm)	Is (MPa)	FC	$Is_{(50)}$ (MPa)	Not Considered
1	25.1	3588.24	59.90	7.00	1.08	7.59	
2	31.9	3156.36	56.18	10.11	1.05	10.65	X
3	28.5	3165.78	56.27	9.00	1.05	9.49	
4	20.7	3373.12	58.08	6.14	1.07	6.56	
5	23.6	3333.30	57.73	7.08	1.07	7.55	
6	21.5	3565.83	59.71	6.03	1.08	6.53	
7	16.5	3489.06	59.07	4.73	1.08	5.10	X
8	28.8	3156.36	56.18	9.12	1.05	9.62	
9	28.2	3227.15	56.81	8.74	1.06	9.26	
10	23.4	3096.65	55.65	7.56	1.05	7.93	

Table 8 - Point load test results for cylinder Graphite rich schist samples.

Sample Number	Graphite rich schist						
N	P (kN)	De² (mm²)	De (mm)	Is (MPa)	FC	$Is_{(50)}$ (MPa)	Not Considered
1	12.40	3395.22	58.27	3.65	1.07	3.91	
2	11.70	3190.48	56.48	3.67	1.06	3.87	X
3	8.10	3023.88	54.99	2.68	1.04	2.80	
4	11.90	3028.88	55.04	3.93	1.04	4.10	X
5	9.50	2819.33	53.10	3.37	1.03	3.46	
6	10.00	2990.20	54.68	3.34	1.04	3.48	
7	11.10	3109.06	55.76	3.57	1.05	3.75	
8	15.10	3121.42	55.87	4.84	1.05	5.09	
9	5.90	3449.78	58.73	1.71	1.08	1.84	X
10	10.00	3006.35	54.83	3.33	1.04	3.47	X

Table 9 - Point load test results for cylinder Quartz biotite schist samples.

Sample Number	Quartz Biotite schist						
N	P (kN)	De² (mm²)	De (mm)	Is (MPa)	FC	$Is_{(50)}$ (MPa)	Not Considered
1	13,00	3678,39	60,65	3,53	1,09	3,85	
2	11,40	3290,05	57,36	3,46	1,06	3,69	X
3	31,00	3786,11	61,53	8,19	1,10	8,99	
4	14,00	3434,22	58,60	4,08	1,07	4,38	X
5	12,20	3810,17	61,73	3,20	1,10	3,52	
6	19,70	3813,61	61,75	5,17	1,10	5,68	
7	12,80	3529,88	59,41	3,63	1,08	3,92	
8	24,30	6268,21	79,17	3,88	1,23	4,77	
9	18,00	4622,39	67,99	3,89	1,15	4,47	X
10	14,40	3365,36	58,01	4,28	1,07	4,57	
11	9,90	3319,49	57,62	2,98	1,07	3,18	X

On Table 10 to Table 12 average results for each different shape sample type are presented. It can be pointed that there was not enough rock amount to produce cylinder samples for quartz biotite schist and irregular samples for graphite rich schist.

Table 10 - Point load test results for cylinder samples (parallel & inclined to foliation).

Lithotype	Loading direction	$Is_{(50)\ AVERAGE}$ (MPa)
GNE	PA	6.48
MSC	IN	8.07
XG	PA	3.48

Table 11 - Point load test results for cylinder samples (perpendicular to foliation).

Lithotype	Loading direction	$Is_{(50)\ AVERAGE}$ (MPa)
GNE	No visible foliation	9.60
MSC	PE	10.21
XG	PE	2.56

Table 12 - Point load test results for irregular samples.

Lithotype	Loading direction	$Is_{(50)\ AVERAGE}$ (MPa)
GNE	PA	1.81
MSC	No visible foliation	7.48
QBX	No visible foliation	4.24

3.4 Correlation Between Uniaxial Compressive and Point Load Strength

Correlations between Uniaxial Compressive and Point Load Strength obtained for all rocks under study are presented on Table 13, considering results for uniaxial compressive strength and point load obtained for cylinder samples with H/D ratio between 2.5 and 3.0, and point load obtained for cylinder samples. The exception being quartz biotite schist, for which results for point load were calculated for irregular samples.

Table 13 - $\sigma_c/Is_{(50)}$ correlations for each lithotype.

Lithotype	Is(50) (MPa)	σc (MPa)	σc/Is(50) Ratio
GNE	6.48	178.84	27.60
MSC	8.07	174.36	21.61
QBX*	4.24	37.93	8.95
XG	3.48	72.37	20.80

*For irregular samples.

4 DISCUSSION

Physical indexes tests results evidence the low porosity of rocks under study – all lower than 2.5%, commonly lower than 1.0%. The densities values are similar to the average values found for metamorphic rocks found in literature (Marques et al. 2010), the exception being the Silica rich carbonated rock (MSC).

Uniaxial compressive strength for studied rocks presents great variations, from values close to 30 MPa (sample QBX-IN 3, Table 3 and sample QBX-IN 1, Table 4) up to values higher than 240 MPa (sample MSC-IN 1, Table 3 and sample MSC-IN 2, Table 4). These data are corroborated by high standard deviation shown on Table 5, which vary from 7.8% to 34.3%, but are usually between 10 to 20%.

These results suggest that point load tests can be used to estimate uniaxial compressive strength, although specific correlations must be provided for each rock type. Another issue that must be pointed is the fact that for very foliated rocks the relation between loading direction and foliation is determinant for the comparison of these two strengths. Greminger (1982), Broch (1983) and Foster (1983) have shown that uniaxial compressive strength can present poor correlations with $Is_{(50)}$ when this last value is determined parallel to foliation, underestimating point load strength. The same behavior was observed for the quartz biotite schist (QBX).

Results obtained for the two H/D ratio studied show that no clear differences can be noted, the exception being found for graphite rick schist. Observed variations for different H/D ratio are inferior to the variations observed for rocks samples tested with the same H/D ratio. No significant differences for uniaxial compressive strength measured for H/D between 2.0 to 3.0 were detected. These results are in accordance with the suggestion of the Eurocode 7 – Geotechnical Project. Also, others researchers as Mogi (1966, 2007), John (1972), Hawkins (1998), Thuro et al. (2001) presented some results for UCS values approximately constant for cores with a H/D ratio of 2.5 or greater. Furthermore, samples with a ratio lower than 2.5 have presented a considerably increase in UCS values. For cores with a H/D ratio between 2.0 to 2.5 the results were inconclusive, with some results almost constant and others showing a little increase of UCS. Finally, Unlu & Yilmaz (2008) have concluded that no significant variation in UCS for sedimentary and magmatic samples with H/D ratios from 0.5 to 3.0 can be observed.

5 CONCLUSIONS

The study allowed the definition of physical and strength properties for four high-grade metamorphic rocks occurring on the south area of Iron Quadrangle, Brazil. Physical properties found on these rocks were similar to those found in literature. Correlations between uniaxial compressive and point load strength determined on this study are also close the most part of the usual value commonly adopted on literature for this relationship, equal to 24. But, generalized conversion factors are not appropriate, as it is necessary to make specific correlations for each kind of rock (Singh et al., 2012). This may be due to the anisotropic nature of the rocks as well as their failure behavior under loading condition.

Finally, regarding H/D ratio, results show that for the studied rocks, there is no significant difference for UCS for the two studied H/D ratios – 2.0 to 2.5 and 2.5 to 3.0.

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