Experimental Study of Rock Strength by Using Friction Transfer Method

Ali Falakian

Department of Civil Engineering, Ramsar Branch, Islamic Azad University, Ramsar, Iran
aliFalakian@yahoo.com

Abstract

As we know, the determination of rock strength by using the examination method, are time consuming and also money consuming. There for, in this research we are going to examine rock strength by using the new friction transfer method. This Method is called friction transfer, because friction making has the main role in power transfer. The examination is according to the following process. First we put a half core with 5 centimeters in diameter exactly at the place of examination. Then we put the friction transfer machine on the cylinder and we enter rotation power in it. Now we can determine the maximum power used for breaking the cylinder. Here we refer to the calibration and determine the strength by friction transfer and related machine, some other experiments have been done in concrete industry. The effect of cylinder depth is another instance that has been studied in this way. Experiments show that as cylinder depth increases form 12 millimeters to 64 millimeters, there would be direct effect. in this research we talked about rock friction strength and calibration curve description. We hope that could be successful in this industry.

Keywords: Friction Transfer, Torque wrench, half core, Rock, Rock strength.

1. Introduction

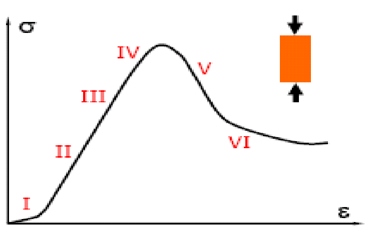
1.1 Mechanical Properties of Rock Materials

1.1.1 Compressive Strength

Compressive strength is the capacity of a material to withstand axially directed compressive forces. The most common measure of compressive strength is the uniaxial compressive strength or unconfined compressive strength. Usually compressive strength of rock is defined by the ultimate stress. It is one of the most important mechanical Properties of rock material, used in design, analysis and modeling.

Figure 1 presents a typical stress-strain curve of a rock under uniaxial compression. The complete stress-strain curve can be divided into 6 sections, represent 6 stages that the rock material is undergoing.

Fig.1. *Typical uniaxial compression stress-strain curve of rock material*



Stage I – The rock is initially stressed, pre-existing micro cracks or pore orientated at large angles to the applied stress is closing, in addition to deformation. This causes an initial non-linearity of the axial stress-strain curve. This initial non-linearity is more obvious in weaker and more porous rocks.

Stage II – The rock basically has a linearly elastic behavior with linear stress-strain curves, both axially and laterally. The Poisson's ratio, particularly in stiffer unconfined rocks, tends to be low. The rock is primarily undergoing elastic deformation with minimum cracking inside the material. Micro-cracks are likely initiated at the later portion of this stage, of about 35-40% peak strength. At this stage, the stress-strain is largely recoverable, as the there is little permanent damage of the micro-structure of the rock material.

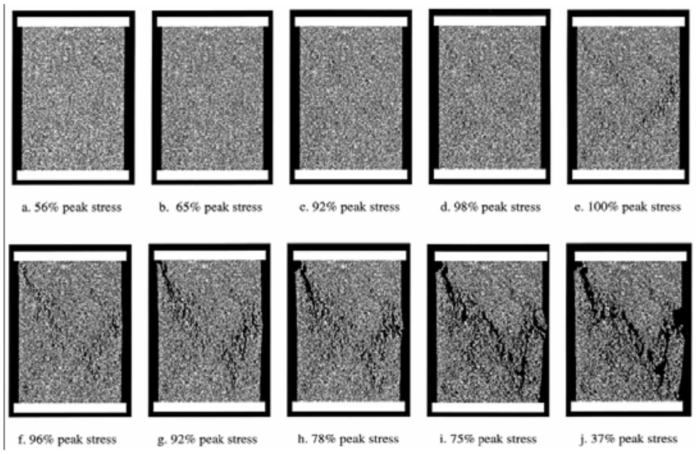
Stage III – The rock behaves near-linear elastic. The axial stress-strain curve is near linear and is nearly recoverable. There is a slight increase in lateral strain due to dilation. Micro crack propagation occurs in a stable manner during this stage and that micro cracking events occur independently of each other and are distributed throughout the specimen. The upper boundary of the stage is the point of maximum compaction and zero volume change and occurs at about 80% peak strength.

Stage IV – The rock is undergone a rapid acceleration of micro cracking events and volume increase. The spreading of micro cracks is no longer independent and clusters of cracks in the zones of highest stress tend to coalesce and start to form tensile fractures or shear planes - depending on the strength of the rock.

Stage V – The rock has passed peak stress, but is still intact, even though the internal structure is highly disrupt. In this stage the crack arrays fork and coalesce into macro cracks or fractures. The specimen is undergone strain softening (failure) deformation, i.e., at peak stress the test specimen starts to become weaker with increasing strain. Thus further strain will be concentrated on weaker elements of the rock which have already been subjected to strain. This in turn will lead to zones of concentrated strain or shear planes.

Stage VI – The rock has essentially parted to form a series of blocks rather than an intact Structure. These blocks slide across each other and the predominant deformation Mechanism is friction between the sliding blocks. Secondary fractures may occur due to differential shearing. The axial stress or force acting on the specimen tends to fall to a constant residual strength value, equivalent to the frictional strength of the sliding blocks

Fig.2. *Uniaxial compression test and failure simulated by RFPA.*

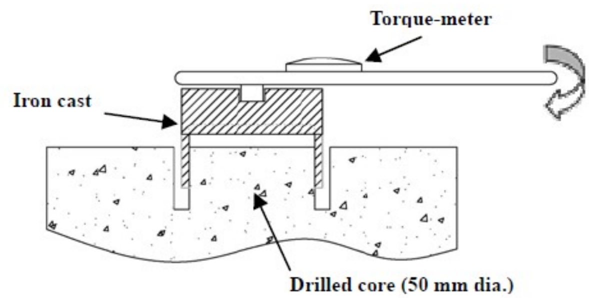


1.2 Friction Transfer Test

The theory behind the Friction-Transfer method is that the twisting of the metallic gripping device causes the concrete within the partial core to fail in torsion Naderi, (2005). Although random diagonal failures usually means that the failure stress are not pure torsional shear stress, it has been found Naderi, (1998) that the most consistent nominal torsional shear strength can be calculated by using the torque required to cause failure in the maximum torsional shear stress–torque relationships. However, as the quality of concrete and mortar is usually assessed in terms of their cube compressive strengths, it is necessary to introduce some form of calibration to estimate this parameter. The Friction-Transfer test, which is used for assessing the bond strength of repair mortars and base concrete in this study, is one such partially destructive method, which has been providing increasing interest as a result of providing tests undertaken in the laboratory and on site Naderi, (1998). The method involves the drilling of a 50 mm diameter partial core with 25 mm depth on the surface of concrete under test and fixing a specially designed gripping device on top of the partial core by fastening its bolts as shown in Figure 3. An ordinary torque-meter is then situated on the gripping device and a gradually increasing torque is applied by hand. As the frictional strength of the gripping device is higher than the torsional strength of the partial core, the latter will eventually fail. Using the shear stress–torque relationship, the failure torsional shear stress is calculated. This can be used to estimate the concrete's equivalent cube compressive strength by means of a previously prepared calibration graph Naderi, (2005).

Fig.3. *Friction-transfer test*

3.a



3.b

2. Materials and Methods

2.1 Rocks Preparation

First, considering the climate, the diversity of rocks and minerals province and neighboring provinces to select the required rocks discussed, Which is selected by the following 4 types of rocks.

2.2 Determining The Measure of Absorption of Water In Rocks

Discussion about the content measure of absorption of water and the total content of moisture in Rocks by some instructions such as ASTM C566-89, ASTM C128-88 to obtain an optimum mixing plan and the accurate measure of concrete's components. The measure of absorption of water in Rocks lave illustrated in table 1.

Table 1. *Particularities of Rocks*

Stone	Density(g/cm3)	Absorption of water (%)
Lime dolomite	2.29	1.80
tuff	2.45	5.60
Brown tuff mudstone	2.58	1.40
Coarse grain lime stone	2.64	0.40

2.3 Coring, Cutting, Grading and Leveling of The Surface of Stone Cylinder Cores With a Diameter of 5 Cm and Depth of 10 Cm

In this level, hence provide from each 4 sort of available stone in 3 cores with a diameter of 5 cm and width of more than 10 cm and 3 half cores with a diameter and depth of 5 cm by core barrel set. Then, cut the cores with width of 10±5 by stone saw.

Since, both tow surfaces of core which is in bearing of strength test plate set, should be quite flat, cut cores with an additional width of +0.5 in order to not having any decreasing width while abrasion and leveling surface. if this level, i.e., leveling and grading of surface is not properly done, the cores is not loading standard and will reach to some quite out spread data, so this level must be done with the most care. Standard determine the following limitations for cylinder cores.

-if the sample diameter is more than 2% in compare with the other section test is not implemented.

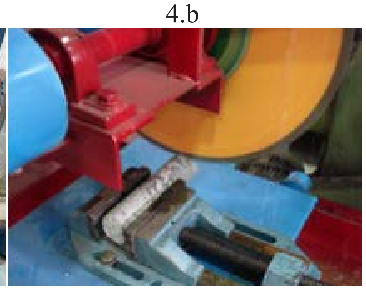
-the end of sample should not have the deviation more than 0.05 in normal along over axis.

-the tow end sample should not be rough more than 0.05.

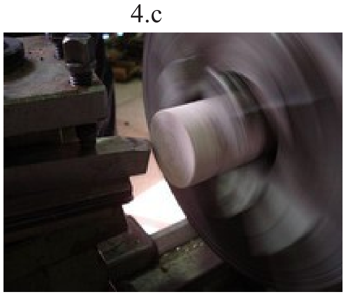
Fig.4. *Coring, Cutting Grading and Leveling*

4.a

4.b



4.c



2.4 Determining The Compressive and Friction Transfer Strength of Rock

In this level, after providing 3 cores with a diameter of 5 cm and depth of 10 cm and 3 half cores with a diameter and depth of 5 cm from each sort of stone and make them flat by standard methods, compute the compressive strength of cores by jack pressure test and also Friction Transfer Strength of half cores with torque wrench like figure 3.

Table 2. *Compressive and Friction Transfer strength of rock*

Stone	Friction Transfer strength of rock (Nm)				Compressive strength of rock (Mpa)			
	Dry		SSD		Dry		SSD	
	strength	Average	strength	Average	strength	Average	strength	Average
Lime dolomite	140	134.667	110	105.000	37.178	37.234	16.806	16.377
	135		109		37.688		16.027	
	129		96		36.834		16.297	
Tuff	152	147.000	92	86.333	60.606	53.831	32.085	30.157
	146		87		54.032		30.375	
	143		80		46.855		28.009	
Brown tuff mud-stone	184	182.000	117	108.667	131.907	122.820	73.338	65.543
	183		107		125.528		68.287	
	179		102		111.026		55.004	
Coarse grain lime stone	204	199.667	130	125.000	145.658	144.735	92.691	87.365
	200		123		144.927		88.935	
	195		122		143.621		80.468	

Compressive and Friction Transfer strength of rock results is illustrated in table 2.

3. Analysis of Data

With implementing the compressive and Friction Transfer strength, over the rock and recording the results in this level, due to the figures 5, 6, 7, 8 are considering the results.

Fig.5. *Comparing Friction Transfer strength of rock (Nm)*

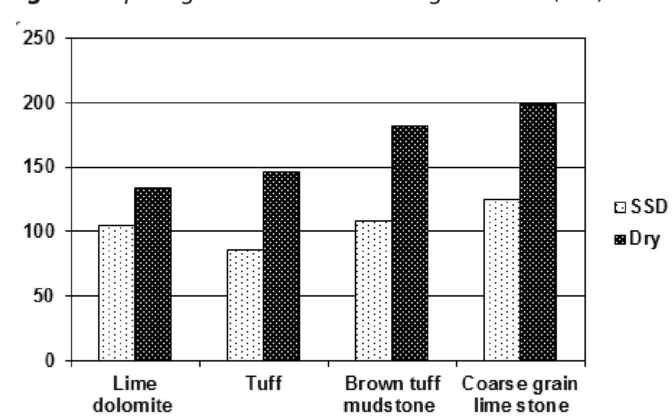


Fig.6. *Comparing Compressive strength of rock (Mpa)*

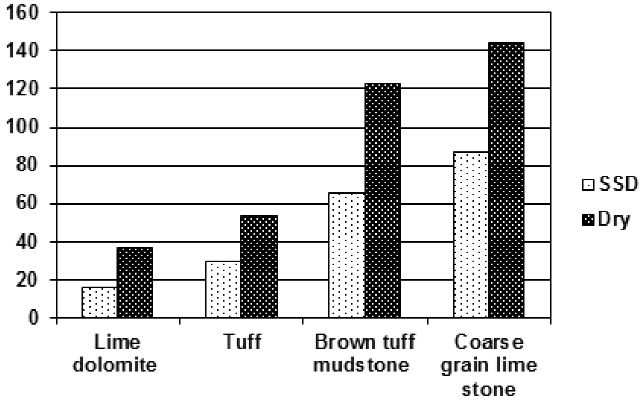


Fig.7. *Relationship between compressive strength and friction strength in the dry state*

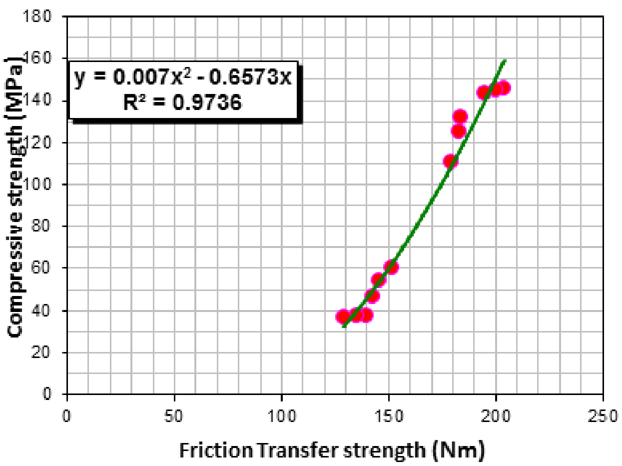
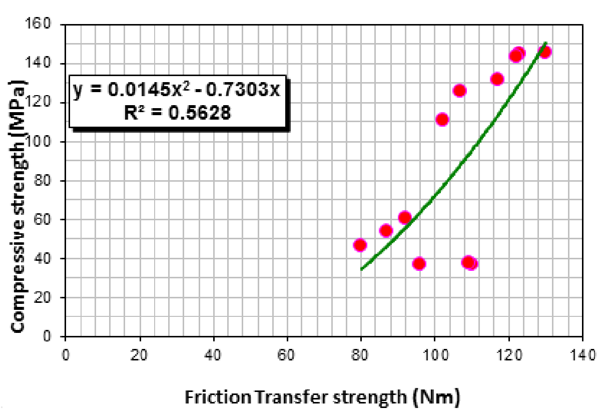


Fig.8. *Relationship between compressive strength and frictional strength to saturation*



4. Conclusion

4.1 By using manual torque wrench and without experienced operator, we can easily implement the torsion test for concrete and rocks which their responses are so accurate.

4.2 By the obtained relations between compressive and twisting strength for rock there is no need to implement time consuming and costly test of mechanic stone in order to achieve the rock strength and easily can be computed by manual torque wrench and without experienced operator.

4.3 Saturated rocks tested in the calibration curves with good correlation of the frictional strength due to the decline in the state are not saturated but Rocks tested in the dry state of calibration curves with correlation coefficients are good.

4.4 By increasing the density of the rock, compressive and frictional strength increase.

4.5 Dolomite limestone is high in saturated and dry frictional strength.

5. Acknowledgement

Thanks of Dr. Mahmood Naderi, because my efforts Did not result without his help .

6. References

1. Jian Zhao, Professor of Rock Mechanics and Tunneling,[2004] Rock Mechanics for Civil Engineers".
2. Aitcin,-P.C;Metha,-P.K, [1990]"Effect of Coarse–Aggregate Characteristics on Mechanical Properties of High-Strength Concrete",ACI-Mater-j, V.87, NO.2, PP.103-107
3. ACI Committee 363, [1997]"State-of-the-Art Report on High-Strength Concrete, ",pp.6-7.
4. High Strength Concrete, [1975] "Manual of Concrete Materials-Aggregates, National Crashed Stone Association, " Washington, D.C.Jan. 16pp
5. Naderi, Mahmood, register of Invention in registration office in Islamic republic of Iran, "Twist-off " test .
6. Naderi, Mahmood, register of Invention in registration office in Islamic republic of Iran, "Friction Transfer" test .
7. P.kumar Mehta, D.J.M.Monterio,[2004] CONCRETE (Microstructure, Properties, and Materials), Advanced concrete technology, university of California , berkely.
8. Hack R, Huisman M (2002) Estimating the intact rock strength of a rock mass by simple means. In: van Rooy JL, Jermy CA (eds) Engineering Geology for Developing Countries—Proceedings of 9th Congress of the International Association for Engineering Geology and the Environment, Durban, South Africa, 16–20 September, pp 1971–1977.
9. Naderi M (2006) Evaluating in situ shear strength of bituminous pavements. In: Proceedings of the ICE-construction materials, vol 159, no. 2, pp 61–65
10. Naderi M (2005) Friction-transfer test for the assessment of in situ strength and adhesion of cementitious materials. Construct Build Mater 19(6): 454–459 CrossRef
11. Naderi M (2008) The use of friction-transfer method in prediction of in situ strength of concrete. Arab J Sci Eng 33(2B)
12. Sonmez H, Gokceoglu C, Medley EW, Tuncay E, Nefeslioglu HA (2006) Estimating the uniaxial compressive strength of a volcanic bimrock. Int J Rock Mech Mining Sci 43: 554–561
13. BS EN ISO 6789 (2003) Assembly tools for screws and nuts. Hand torque tools. Requirements and test methods for design conformance testing, quality conformance testing and recalibration procedure