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SCOPE AND BACKGROUND

International Symposium on Earth Science and Technology 2012 is organized by The Cooperative International–Network for Earth Science and Technology (CINEST). This symposium highlights the reason achievement in the fields of Mineral Resources, Energy and Environment based on the Earth Science and Engineering. The symposium includes special session on the Kyushu University G-COE “Novel Carbon Resource Sciences” and ITP, JSPS. Interdisciplinary studies and discussions on the future directions of the fields are focused, and especially young researchers contributing to earth resources development and global environment are strongly encouraged.

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FIELD TRIP

Day 1 (September 20, 2012)
Geological Museum

This museum was established on May 16, 1928 and later was renovated with the funding assistance from JICA (Japan International Cooperation Agency). In the museum, you can obtain various information related to geology and see some interesting collections, such as the skull (fossil) of first human being in the world, the skeleton fossils of prehistoric animals, 156 kg meteorite that fell on March 30, 1884 at Jatipelangon, Madiun. As a historic monument, this museum is considered a national heritage and is protected by government regulations. It stores and manages abundant geological materials, such as fossils, rocks, and minerals gathered during the fieldwork in Indonesia since 1850.

White Crater on Mt. Patuha

Kawah Putih (means white crater) is situated on the top of Mount Patuha in South Bandung (50 km south of Bandung). The lake is 2,430 meters above sea level so the local climate is often quite chilly (temperatures are frequently around 10 degrees celsius). The color of the crater is apple green because it contains sulfur. Hydrothermal water-rock interactions in the Kawah Putih system constitute a present-day example of volcanic ore-deposit formation. Precipitation of native sulfur and other sulfides from lake waters have accumulated as extensive sulfur-rich sediments on the lake bottom. Abundant seepage of Kawah Putih's lakewaters into fractures is another mechanism of hydrothermal ore formation in the volcano.

Day 2 (September 21, 2012)
PT. JGC Coal Fuel Karawang

JGC Corporation announced that it has completed in Indonesia construction of a demonstration plant for the production of a slurry type new fuel called JGC Coal Fuel (JCF®). An inauguration ceremony was held, attended by Indonesian and Japanese government officials, as well as JGC's business partners, at the plant site in Karawang, Indonesia, about 50 km east of Jakarta. Now in operation, the plant has a capacity of approximately ten thousand tons/year. This is a significant milestone for JCF® business development in Indonesia.

INTERNATIONAL SYMPOSIUM ON EARTH SCIENCE AND TECHNOLOGY

SYMPOSIUM SCHEDULE

Tuesday, 18th September 2012			
TIME	SCHEDULE		
07.30 - 08.00	Registration		
08.00 - 08.55	Opening		
09.10 - 10.25	Keynote Speech		
10.40 - 11.55	Room A (ITP)	Room B (G-COE)	Room C (ERGE & MPMT)
11.55 - 13.00	Lunch (Aula Timur ITB)		
13.00 - 15.05	Room A (ERGE)	Room B (EAE)	Room C (REA)
15.40 - 17.20	Room A (ERDMT & MPMT)	Room B (ERGE & EAE)	Room C (ERDMT)
17.20 - 17.55	Poster Session (Aula Barat ITB)		
18.30 - 20.00	Banquet (Aula Timur ITB)		
Wednesday, 19th September 2012			
TIME	SCHEDULE		
08.00 - 10.05	Room A (ERGE)	Room B (REA)	Room C (ERDMT & REA)
10.20 - 12.00	Room A (ERGE)	Room B (ERGE & ERDMT)	Room C (ERDMT)
12.00 - 13.00	Lunch (Aula Timur ITB)		
13.00 - 15.05	Room A (ERGE)	Room B (EAE)	Room C (ERDMT)
15.30 - 17.10	Room A (ERGE)	Room B (EAE)	Room C (ERDMT & MPMT)
17.10 - 17.30	Closing Session and Award Ceremony (Aula Barat ITB)		

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Using the Schmidt Hammer on Rock Mass Characteristic in Sedimentary Rock at Tutupan Coal Mine

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Abstract

The uniaxial compressive strength is one of important parameter to determine the shear strength of rock mass by the rock classification method. To determine uniaxial compressive strength used by a testing on laboratory or in practically can use the index method, in this research, alternatively is to use Schmidt Hammer. A method used Schmidt Hammer to determine the uniaxial compressive strength of rock is to calibrate between Schmidt Hammer Rebound (R) and uniaxial compressive strength test of laboratory and its the results are an empirical equation. The advantage of this method can practically to assess the strength of rocks in the field. At this paper is one of the alternative uses of the uniaxial compressive strength determining in sedimentary rocks in Warukin Formation at Tutupan open pit coal, South Kalimantan, Indonesia. And the next research is going to process towards another formation.

1. Introduction

The management of Open Pit Adaro coal mine is very concerned with keeping slopes stable because the pit is currently being mined at a very deep level, about 190 m below the original surface, some areas are very steep and it stretches 17 km from south to north east. The coal bearing strata is dominated by weak and friable to medium strong sandstone and mudstone of young formation (Warukin Formation) and in particular the mine experiences high rainfall. Having learned the local environmental condition, it is apparent that the most influence factor to the potential slope failure is the strength deterioration of the coal bearing strata. Currently, the coal mining in Tutupan mine PT. Adaro Indonesia has reached a depth of more than 190 m with elevations as low as -98 mRL and this will get deeper to a depth of -204 mRL in order to fulfill the world coal demand. One of method determine uniaxial compressive strength is index method the Schmidt Hammer (SH).

The SH originally designed for testing the hardness of concrete in 1948 was first used in a geomorphological context in the 1960s. The SH have become the advantages and disadvantages of the device for measuring rock characteristics and has been used for an increasing range of purposes, including the study of various weathering phenomena a range.

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2. Previous Studies

The instrument measures the distance of rebound of a controlled impact on a rock surface. There are now several version of the hammer. The 'N' type it can provide data on a range of the rock types from weak to very strong with compressive strengths that range from 20 to 250 MPa. The 'L' type hammer has an impact tress time lower than the'N' type and the 'P' type is a pendulum hammer for testing materials of very low hardness, with compressive strength of less than 70 kPa. When the SH is pressed against a surface, its piston is automatically released onto the plunger. Part of the piston's impact energy is consumed by absorption and is transformed into hear and sound. The remaining energy represents the impact penetration resistance of the surface. This enables the piston to rebound. The distance traveled by the piston after it rebounds is called the rebound value (R). Harder rocks have higher R values (Gaudie, 2006). Rebound values are influenced by gravitational forces to varying degrees so that non-horizontal rebound values must be normalized with reference to the horizontal direction (Day &Gaudie, 1977). The R Value is shown by a pointer on a scale on the side of the instrument (range 10 – 100). It us therefore important that the Schmidt Hammer is used with care and that it is properly calibrated (McCarroll, 1987).

A very substantial number of R value has been obtained from many different rock types in many parts of the world (Gaudie, 2006). At one end of the scale 'weak' rocks such as chalk, aeolianite and marls have low compressive strength. At the other end, silicates, very hard limestones, quarzites, and various igneous rocks many have values that exceed 60, and very occasionally 70.

Goudie (2006) made conclusion of used of the SH that the SH is a convenient means of establishing rock hardness in the field, providing that certain precautions are taken in the light of its known limitations. Portable, cheap, free from operator variance, simple and easy calibrated and free from any noticeable temperature effects, it can with due care produce rock hardness values that correlate well with such parameters as uniaxial compressive strength or Young's Modulus of Elasticity.

The SH tests are increasingly quantitative. The latter is recommended for obtaining estimates of wall strength for subsequent calculation of shear strength, when utilizing the wall roughness coefficient (JRC) described under roughness.

Selby (1993) has divided rocks up into 6 classes (Table 1). This provides a useful basis for classifying rocks and forgiving a clear indication of a rock's character.

Because of its speed, simplicity, portability, low cost and non-destructiveness, the SH has been used as a means of estimating other rock properties, such as compressive strength (Sendir, 2002). Various researchers have studied the relationship between rock compressive strength and SH R values as shown Table 2. The R^2 value has range between 0.7 and 0.99 (Yasar&Erdogan, 2004). The regressions vary greatly between different rock type, however (Dincer et al., 2004) and so should be used only for particular lithologies (Sachpazis, 1990). Nonetheless, as Hack and Huisman (2002) point out, a large number of simple test in the filed, using the SH, will tend to give a better estimate of the intact rock strength at various location than a limited number of more complex test.

3. Proposed Equation

As mentioned before that the equation of SH (Goudie, 2006) include the UCS of varied rock that is obtained from non-tropical countries. The samples are obtained from coal bearing strata that is located in the tropical country so that rock strength deterioration due to weathering is taken into account. The weathering process is simulated through slake durability tests. It is expected that the proposed equation will be more representative than the previous one in the application for estimate for uniaxial compressive strength in Indonesian open pit coal mine.

Rock mass characterization studies produce empirical equation relationship between the uniaxial compressive strength and the SH Rebound (R) shown the power function (Figure 1).

The previous researchers gave the R value for mudstone and sandstone that varies is between 10 and 38.6 for the mudstone and 10 to 44.7 for sandstone (Table 3). While the value of R for the mudstone and sandstone of the cover turned out to be among the respective 10 – 26 and 10 – 28.

The previous researchers provide empirical equation of the relationship uniaxial compressive strength and Schmidt Hammer Rebound with varied functions, logarithmic functions, exponential, power, and linear (Table 4). The purposed empirical equation for estimate UCS to weak rock on the coal bearing strata in Warukin Formation, is:

$$UCS = 0.308R^{1.327} \quad (1)$$

where: UCS= uniaxial compressive strength (MPa), R = Schmidt hammerrebound

Table 1. Approximate strength classification of rocks (Selby, 1993)

Description	Uniaxial compressive strength, MPa	Point load strength $I_{s(50)}$, MPa	Schmidt Hammer N-Type, 'R'	Characteristic rocks
Very weak rock – Crumbles under shrap blows with geological pick point, can be cut with pocket knife.	1-25	0.04-1.0	10-35	Weathered weakly Compacted sedimentary rocks-chalk, rock salt
Weak rock – shallow Cuts or scraping with pocket knife with difficulty, pick point indents deeply with firm blow	25-50	1.0-1.5	35-40	Weakly cemented Sedimentary rocks – coal siltstone, also schist
Moderately strong rock – knife cannot be used to scrape or peel surface, shallow indentation under firm blow from pick point	50-100	1.5-4.0	40-50	Competent sedimentary Rocks – sandstone shale, slate
Strong rock – hand-held sample breaks with one m firm blow from hammer end of geological pick	100-200	4.0-10.0	50-60	Competent igneous and Metamorphic rocks – marble, granite, gneiss
Very strong rock – requires many blows a from geological pick to break intact sample	>200	>10	>60	Dense fine-grained igneous snd metamorphic rocks – quartzite, dolerite, gabbro, basalt.

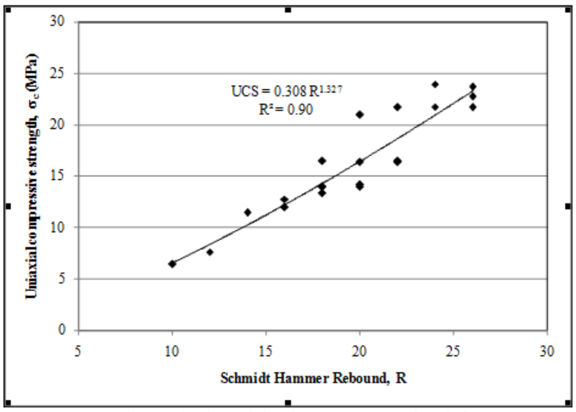

Figure 1. The relationship between uniaxial compres- sive strength and the Schmidt Hammer Rebound (R)

Table 2.Correlation between Schmidt hammer rebound and uniaxial compressive strength and Young's modulus (Gaudie, 2006)

Equation	R^2	Reseacher	Lithology
UCS			
$UCS = 6.9 \times 10^{(0.0087\gamma R + 0.16)}$	0.94	Deere and Miller (1966)	varied
$UCS = 6.9 \times 10^{(1.348\gamma R - 1.325)}$	-	Aufmuth (1973)	varied
$UCS = 0.447\exp(0.045(R + 3.5) + \gamma)$	-	Kidybinski (1980)	Coal, Shale, mudstone
$UCS = 2R$	0.72	Singh et al. (1983)	Sandstone, siltstone
$UCS = 0.4RLM – 3.6$	0.94	Sheorey et al. (1984)	Coal
$UCS = 0.994R – 0.383$	0.70	Haramy and De Marco (1985)	Coal
$UCS = 702R - 1104$	0.77	O'Rourke (1989)	Sandstone
$UCS = 2.208e^{0.067R}$	0.96	Katz et al. (2000)	Limestone, sandstone
$UCS = \exp(0.818 + 0.059R)$	0.98	Yilmaz and Sendir (2002)	Gypsum
$UCS = 2.75R – 36.83$	-	Dincer et al (2004)	Andesite, basalts, tuffs
$UCS = 2.22R – 47.67$	-	Aggistalls et al (1996)	Gabbros, basalts
E			
$E = 6.95\gamma^2R – 1.14 \times 106$	0.88	Deere and Miller (1966)	Varied
$E = 6.9 \times 10^{(1.06 \log(\gamma R) + 1.86)}$	-	Aufmuth (1973)	varied
$E = 0.00013R^{3.09074}$	0.99	Katz et al. (2000)	Syenite, granite
$E = \exp(1.146 + 0.054R)$	0.91	Yimaz and Sendir (2002)	gypsum

UCS = Uniaxial compressive strength (MPa), E = Young's modulus (MPa), R = Schmidt hammer rebound number, γ = rock density (gr/cm^3) (Yasar&Erdogan (2004)

Table 3. Schmidt Hammer rebound (R) of sandstone and mudstone

No	**Lithology**	**Country**	**Schmidt hammer 'R'**	**researchers**
1	**Mudstone**	**Jepang**	**10.5 – 32**	**Hayakawa &Matsukara (2003)**
2	**Mudstone**	**Ankara, Turkey**	**27.1 – 38.6**	**Gokceogal&Aksoy (2000)**
3	**Mudstone**	**Kaikoura, New Zealand**	**32 – 35**	**Stephenson & Kirk (2000)**
4	**Mudstone**	**Tutupan, Indonesia**	**10 – 26**	**Saptono&Kramadibrata**
5	**Sandstone**	**Ankara, Turkey**	**18.3 – 33.6**	**Gokceogal&Aksoy (2000)**
7	**Sandstone**	**South East, Jordan**	**41 – 44.7**	**Goudie, et al (2002)**
8	**Sandstone**	**Tutupan, Indonesia**	**10 – 28**	**Saptono&Kramadibrata**

Table 4. Proposed equation correlation between Schmidt hammer rebound and uniaxial compressive strength

Equation	**R^2**	**Researcher**	**Lithology**
$UCS = 6.9 \times 10^{[0.0087\gamma R + 0.16]}$	**0.94**	**Deere & Miller (1966)**	**varied**
$UCS = 6.9 \times 10^{[1.348 \log(\gamma R) – 1.325]}$	**-**	**Aufmuth (1973)**	**varied**
$UCS = 0.447\exp^{[0.045(R + 3.5) + \gamma]}$	**-**	**Kidybinski (1980)**	**coal, shale, mudstone**
$\underline{UCS = 0.308\ R^{1.327}}$	**0.90**	**Saptono&Kramadibrata**	**sandstone, mudstone**
$UCS = 2R$	**0.72**	**Singh et al (1983)**	**sandstone, mudstone**
$UCS = 2.75R – 36.83$	**-**	**Dincer et al (2004)**	**Andesite, basalt, tuff**
$UCS = 702R - 1104$	**0.77**	**O'Rourke (1989)**	**sandstone**

4. Concluding Remarks

Determination of measurement the weak rock strength in the field we need a method that is fast, easy and precise so one of method is to use the index measuring device, which use Schmidt Hammer Rebound. Its result is a function empirical equation of relationship between uniaxial compressive strength and Schmidt hammer rebound (R). This research would be to replace qualitative geological hammer in sedimentary rock in coal bearing strata in Warukin Formation. This research is going to process towards another formation in tropical country as Indonesia.

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