



Proceedings of
**International Symposium on
Earth Science
and Technology 2013**

December 3 - 4, 2013

Inamori Foundation Memorial Hall

Kyushu University, Fukuoka, Japan

Organized by

Cooperative International Network for Earth Science and Technology (CINEST)

Sponsored by

RA
N UPN
 **MITSUI MATSUSHIMA CO., LTD.**

Supported by

**Mining and Material Processing Institute of Japan (MMIJ) Kyushu Branch
MMIJ-Division of Coal Mining Technology**

Contents

| Paper No. | Paper Title and Authors | Page |
|---------------|--|------|
| Prenary I | Educating Managers and Leaders for Sustainable and Socially Responsible Mining in Africa Jean-Paul FRANZIDIS | 1 |
| Prenary II | Energy Efficiency Improvement Opportunities in the Mineral Industry Raj SINGHAL, Kostas FYTAS | 3 |
| 01 | Information and System Management in the Framework of the Project: Innovation of Bc and Ms Study Programmes at the Faculty of Mining and Geology, VSB-Technical University of Ostrava (INO HGF) Oldrich KODYM | 8 |
| 02 | Development of New Type Expansion Rock Bolt Yun-Young Jeong, Sang-Ho Cho, Sang-Sun Jeong | 14 |
| 03 | Visualization of Methane Flow in Area with Two Degassing Boreholes Pavel STASA, Oldrich KODYM, Miroslav STOLBA | 18 |
| 04 | Study on Estimation of Re-entry Time after Blasting in Underground Mining PT Cibaliung Sumberdaya, Indonesia Sandro Hanaehan SIRAIT, Nuhindro Priagung WIDODO, Mikha SIMANJUNTAK | 24 |
| 05 | Support Design of Cut and Fill Mine Method at Underground Gold Mine PURWANTO, Hideki SHIMADA, Takashi SASAOKA Kikuo MATSUI, Ridho WATTIMENA | 29 |
| 06 | Discontinuity Spacing Correction Factor on Predicting Penetration Rate of Rotary-Percussive Drill: The Laboratory Scale Model Ganda M. SIMANGUNSONG, Prathama I. FEBRIANTO, Suseno KRAMADIBRATA | 37 |
| 07 | Bearing Capacity Correlation by Using Dynamic Cone Penetrometer Test and California Bearing Ratio Test for Mining Equipment Recommendation Barlian DWINAGARA, Oktarian Wisnu LUSANTONO | 43 |
| 08 | Geotechnical Study for Optimizing the Outpit Dump at PT Bhumi Rantau Energi Open Pit Coal Mine Budi Sulistianto, Kristijulantika Agustian, Tri Karian Ginting Jalu Kusuma, Cecep H. Setiadi | 48 |
| 09 | Assigning Economic Values on Mining blocks and Cut-off Grade Determination by Break-Even Analysis: A Case Study of the Marampa Iron Ore Deposit. Abu Bakarr Jalloh, Kyuro Sasaki | 54 |
| 10 | Recycling of Trash Mixture Tsunami Sludge by using Screening and Improvement Hiroshi TAKAHASHI, Shinya IZUMI, Satoshi SHIBATA, Masato MORI | 59 |
| 11 | Removal of Cesium, Cobalt, Strontium, or Some Other Metals Detected Around Fukushima from the Aqueous Solution Using Microbial Cells Takehiko TSURUTA, Kazuya SAWAMUKAI, Ryohtaroh NAKAMURA Shun OGASAWARA, Rie NATSUBORI, Daishi UMENAI | 64 |

| Paper No. | Paper Title and Authors | Page |
|-----------|--|------|
| 12 | A Preliminary Study on the Simulation of the Effects of Parameters on Hydraulic Fracturing of a Horizontal Well in a Shale-Oil Reservoir Sujaree WORAPOTPISAN, Chatsuda KULTAVEEWUTI, Supol JIARASUPHAT Svein Tore OPDAL, Kreangkrai MANEEINTR | 70 |
| 13 | Codeposition of Silica with Suspended Particles in Porous Media Loren TUSARA, Ryuichi ITOI, Yoshitaka KAWAHARA, Daisuke FUKUDA, Osamu KATO | 77 |
| 14 | EOR Development Screening of A Heterogeneous Heavy-Oil Field in Southern of Oman Using Steam Flooding Ibrahim Al HADABI, Kyuro SASAKI, Yuichi SUGAI | 83 |
| 15 | Natural State Numerical Model of Lahendong Geothermal Reservoir, North Sulawesi, Indonesia Ali ASHAT, Nurita Putri HARDIANI, Ahmad YANI, Ryuichi ITOI | 87 |
| 16 | Numerical Simulation of Groundwater Flow and Heat Transportation in Krang Volcanic Area, Indonesia Aiko HARADA, Ryuichi ITOI, Boy Yoseph CSS Syah ALAM | 93 |
| 17 | Recharge Source and Groundwater Flow System in Mt. Karang West Java, Indonesia Based on the Stable Isotopes Boy Yoseph CSS SYAH ALAM, Ryuichi ITOI, Sachihiro TAGUCHI | 99 |
| 18 | Granitic Magmatism and Related Ore Deposit in Sulawesi, Indonesia Adi MAULANA, Kotaro YONEZU, Koichiro WATANABE, Akira IMAI | 108 |
| 19 | Sr-Nd-Hf Isotope Geochemistry of Early Yanshanian Granitoids in Central Nanling Region, South China: Implications for Magmatic Evolution and Tectonic Environment Huan LI, Koichiro WATANABE, Kotaro YONEZU | 112 |
| 20 | Characterizations of LREE or Nd Doped Aluminosilica Gels by Sol-Gel Method for Preparing a Calibration Curve with High Accuracy Junya KANEMITSU, Kotaro YONEZU, Koichiro WATANABE, Takushi YOKOYAMA | 120 |
| 21 | RFID Technology in Industrial Environments with Risk of Explosion Pavel STASA, Jiri SVUB, Zbynek KOCUR, Jakub UNUCKA | 123 |
| 22 | Utilization of RFID Technology in Transportation Systems of Opencast Mine Filip BENES, Pavel STASA, Jiri SVUB, Vladimir KEBO | 129 |
| 23 | Reliability of Reading in Management System Based on AIDC Technology for Special Goods and Processes. Juraj VACULÍK, Peter KOLAROSZKI, Jiří TENGLER | 133 |
| 24 | Radio Frequency Identification of Metal Objects and RF Transparent Containers Filled Up with Liquids Jiri SVUB, Vladimir KEBO, Jakub UNUCKA, Lukas VOJTECH | 139 |
| 25 | The Use of RFID Technology in Underground Coal Mines Environment Vladimir HON, Milan ODRIHOCKY, Milan KRPEC, Pavel BENDA, Vladimir KEBO | 143 |

| Paper No. | Paper Title and Authors | Page |
|-----------|---|------|
| 26 | The Use of Physical Model to Predict Surface Subsidence of Prototype by using Dimensional Analysis Tri KARIAN, Suseno KRAMADIBRATA, Budi SULISTIANTO | 147 |
| 27 | Stability Control of Roadway in Protected Seam of Deep High-gas Multi-seams through Ascending Mining in China Deyu QIAN, Takashi SASAOKA, Hideki SHIMADA, Kikuo MATSUI, Cheng WANG | 154 |
| 28 | Mechanism of Localized Stress Concentration in Interlayer Rock Mass and Its Impact on Deep Multi-seam Mining Mingwei ZHANG, Takashi SASAOKA, Hideki SHIMADA, Kikuo MATSUI | 161 |
| 29 | Geotechnical Issues of Narynsukhait Open Pit Coal Mine Tsedendorj AMARSAIKHAN, Ryo YAMAMOTO, Akihiro HAMANAKA, Deyu QIAN, Takashi SASAOKA, Hideki SHIMADA, Kikuo MATSUI | 169 |
| 30 | Post Closure Water Quality Simulation of Mangkalapi Pit in Batulicin Coal Mine, South Kalimantan, Indonesia. Sendy DWIKI, Rudy Sayoga GAUTAMA, Fatimah KOTEN, Hideki SHIMADA, Ginting Jalu KUSUMA | 174 |
| 31 | Preliminary Assessment of Groundwater Contamination Hazard in Open Pit Coal Mine, Barito Timur, Central Kalimantan, Indonesia Shofa Rijalul HAQ, Doni Prakasa Eka PUTRA, Barlian DWINAGARA | 180 |
| 32 | Study of Silicate Coating on Pyrite Oxidation Suppression: Fundamental Mechanism and Kinetic Analysis Hajime MIKI, Tsuyoshi HIRAJIMA, Mutia Dewi YUNIATI, Keiko SASAKI | 189 |
| 33 | Electrochemical Study of Silicate Coating on Sulphide Minerals Oxidation Suppression Mutia Dewi YUNIATI, Tsuyoshi HIRAJIMA, Hajime MIKI, Keiko SASAKI | 193 |
| 34 | Atmospheric Leaching Behavior of East Java Chalcopyrite Ore in Sulfuric Acid Solution and Hydrogen Peroxide as Oxidizing Agent M.Z. MUBAROK, A. DILOVA | 197 |
| 35 | Leaching Behavior of Nickel from Indonesian Nickel Laterite Ores by Atmospheric Acid Leaching Using Citric Acid Widi ASTUTI, Tsuyoshi HIRAJIMA, Keiko SASAKI, Naoko OKIBE | 202 |
| 36 | Purification of MgCl ₂ Solution Generated By Leaching of Ferronickel Smelting Slag for Preparation of MgO Powder A. YUDIARTO, M.Z. MUBAROK | 206 |
| 37 | Delineating Biodiversity Conservation Corridors Using Analytic Hierarchy Process (AHP) and GIS: A Case Study in Thua Thien Hue Province, Central Vietnam Nguyen Tien HOANG, Pham Van HUYNH, Katsuaki KOIKE | 211 |
| 38 | Construction of a GIS Comprehensive Base System for the Development, Circulation and Utilization of Geospatial Information Poppy INDRAYANI, Yasuhiro MITANI, Ibrahim DJAMALUDDIN and Hiro IKEMI | 217 |

Bearing Capacity Correlation by Using Dynamic Cone Penetrometer Test and California Bearing Ratio Test for Mining Equipment Recommendation

Barlian DWINAGARA¹, Oktarian Wisnu LUSANTONO²

¹ Mining Engineering Department, UPN "Veteran", Yogyakarta, Indonesia

² Graduated Student from Mining Engineering Department, UPN "Veteran", Yogyakarta, Indonesia

ABSTRACT

Coal mining in Indonesia has grown larger in the late century. According to a great market demand to fulfill coal supply, the coal mining company increases the coal production. Therefore, the coal mine area would be expanded to increase coal production and it needs study. Furthermore, one of the studies is bearing capacity study which is required to expand pit area. Purpose of this study is to determine the correlation of two bearing capacity methods and give the recommendation for appropriate mining equipment in field. Dynamic Cone Penetrometer (DCP) test and California Bearing Ratio (CBR) test are two methods, which are compared to obtain the best value of bearing capacity. Clay, coal, sandy clay materials are tested as sample materials. The result of this study indicates that bearing capacity value from DCP test is higher than CBR test. An increment and degresion of bearing capacity value of DCP test are not followed by CBR test, it can be concluded that bearing capacity value of CBR test is used as basic reference to recommend the mining equipment. As the result, ground pressure of mining equipment would not be more than 124kPa, as recommendation.

Keywords : bearing capacity, DCP test, CBR test, correlation

INTRODUCTION

To expand mining area requires several studies, one of them is bearing capacity study. This study aims to provide a mine equipment recommendation that could be applied in the mine are. PT. Senamas Energindo Mineral (PT. SEM) one of the mining company would like to do this study. PT. SEM is a mining company located in Central Kalimantan with an Mining Business Permitted Area approximately 2000Ha. PT. SEM will expand the mining area in Pit 2 and Pit 3, thus it will needs bearing capacity for some existing material. Studies of bearing capacity required testing that could be done either insitu or laboratory with certain condition.

OBJECTIVES

The objectives of this study is to determine the mine equipment recommendation based on materials bearing capacity in Pit 2 and Pit 3 of PT. SEM.

METHODOLOGY

This study tested bearing capacity using insitu or laboratory test. Insitu bearing capacity test is using Dynamic Cone Penetrometer (DCP). Laboratory test for bearing capacity using California Bearing Ratio test (CBR).

Firstly sampling point has been determined. After that, DCP test could be done at the location. After completing DCP test, followed by material sampling at the same point for CBR test.

For any laboratory test, sample always need preparation phase. Therefore, before entering CBR test,

the sample must be prepared. Once the preparation has done, continued for physical test and proctor test.

After getting the bearing capacity value from both testing, the result will be correlated by using scatter diagram and linier regression. The correlation result used as a basic recommendation for determining mine equipment.

SOIL DEFINITION

Soil has several definitions in several disciplines. According to civil engineering expert, soil is defined as a natural aggregate of mineral grains that can be mechanically separated as soluble in water. According to experts in geological engineering, soil definition is the result of weathering of rock material that can be caused by plants. From those opinions could be concluded that soil is the result of weathering of rock material consisting of organic and inorganic material (Terzaghi, 1996).

Soil Classification

Soil has a certain grain size that can determine the type of soil. Determination of the type of soil called soil classification (Terzaghi, 1996). Existing soil classification methods vary, but the commonly used method is the Unified Soil Classification System (USCS). USCS soil classification method introduced by Casagrande (1948) further refined by the U.S. Corps of Engineer and Bureau of Reclamation (USBR) in 1963 in Soil Mechanics for Engineering Practices by Karl Terzaghi (1996).

According to USCS soil classified by grain size, percent escapes, and consistency limits (see Figure 1). To determine these parameters based on ASTM D2487 testing

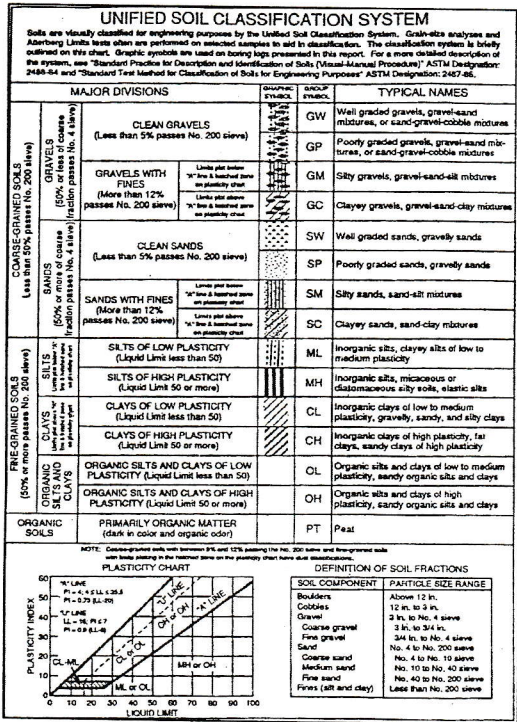


Fig 1. Unified Classification Soil System

BEARING CAPACITY TEST

Dynamic Cone Penetrometer Test

Bearing capacity could be done by insitu test using Dynamic Cone Penetrometer (DCP) test. DCP test done by wham load from a certain height to measure penetration rate per blow at the certain depth (Luo, 1998 in Perancangan Perkerasan Jalan dan Penyelidikan Tanah by Harry Christady, 2010). The testing procedure based on ASTM D6951/6951M. In general, DCP consist of two rods with one conical tipped and expenses (See Figure 2).

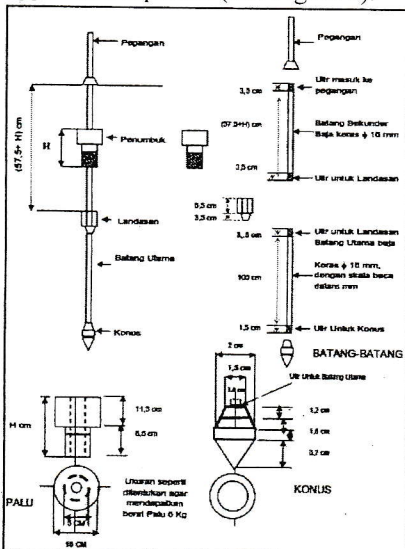


Fig 2. DCP Equipment

From DCP testing results will be obtained data sum pe blow number and depth of penetration. According to the United States Army Engineer (USAE) formulated as follows:

$$PI = \frac{\Delta Dp}{\Delta B_c} \dots \dots \dots (1)$$

Description :

- PI = Penetration Index (DCP Value)
- ΔD_p = Penetration depth (mm)
- ΔB_c = Sum of Blow based on penetration

Based on Webster (1992) in Perancangan Perkerasan Jalan dan Penyelidikan Tanah by Harry Christady (2010) bearing capacity value could be obtained by CBR value from DCP test. The correlation of DCP and CBR value formulated as follows :

$$\text{Log (CBR)} = 2.46 - 1.12 \text{ log (PI)} \dots \dots \dots (2)$$

Description :

- CBR = CBR value (%)
- PI = Penetration Index/DCP value (mm/blow)

California Bearing Ratio Test

Bearing capacity test conducted in laboratory using California Bearing Ratio (CBR) test. CBR test could be done by natural sample condition or modifying sample condition to saturated. CBR testing based on ASTM D1883. CBR testing is done by compacting sample in mold and conditioning sample in some ways then penetrate the piston with rating of 0.1 inches to a compacted sample (Yoder&Witzak, 1975).

CBR value can be determined by the following formula :

$$CBR_{0.1} = \frac{\text{Corrected Weight (P)}}{3 \times 1000} \times 100\% \dots \dots \dots (3)$$

With P value obtained from :

$$P = k \times \text{dial} \dots \dots \dots (4)$$

Description :

- k = callibration (lbs)
- dial = dial measurement (div)

BEARING CAPACITY

Bearing capacity is the ability of soil to withstand the load when the land was given as the burden of loading foundation and mechanical equipment without inducing collapse (Meyerhoff, 1947 in Soil Mechanics for Engineering Practices 1996). Bearing capacity can be determined by USAE formula as follows :

$$BC = 1.6649 + 4.3592 \text{ log CBR} \dots \dots \dots (5)$$

Description :

- BC = Bearing Capacity (kg/cm²)
- CBR = CBR value (%)

GROUND PRESSURE

A mine equipment placed above materials will provide ground pressure. Wheels burden for each vehicle determined based on the specifications of the manufactures. In each calculation, the largest wheel loads used as the basis for determining load and bearing capacity. If the subgrade is capable to support the greatest load on the wheel, the smaller wheel does not need to be taken. Mine equipment ground pressure can be adjusted to type, brand and used equipment.

CORRELATION ANALYSIS

Correlation is the relationship between the two variables is positive and negative (Supranto, 1990). Correlation analysis can be determined using scatter diagram.

In this study, the correlation is carried out by simple linear regression analysis. Linear regression can be used to predict, seek, and find out the relationship. The magnitude of the effect of independent variables on the dependent variables can be expressed by the coefficient of determination (r^2).

DATA AND STUDY

DCP Test Data

DCP test conducted at 15 different points in Pit 2 and Pit 3 with three different materials, clay, sandy clay and coal. DCP test result can be seen in Table 1 and Table 2. Bearing capacity value based on DCP test result using USAE formula (see equation 5) can be seen in Table 3.

Table 1. DCP Test Result in Pit 2

| Sample Code | Lithology | DCP (mm/blow) | CBR (%) |
|-----------------|------------|---------------|---------|
| Pit 2 DCP LW B1 | Sandy Clay | 26,00 | 7,60 |
| Pit 2 DCP LW B2 | | 13,81 | 21,45 |
| Pit 2 DCP LW B3 | | 33,14 | 8,00 |
| Pit 2 DCP LW B4 | | 29,71 | 54,21 |
| Pit 2 DCP LW A1 | Coal | 2,76 | 93,59 |
| Pit 2 DCP LW A2 | | 3,05 | 116,01 |
| Pit 2 DCP LW A3 | | 9,81 | 84,66 |

Table 2. DCP Test Result in Pit 3

| Sample Code | Lithology | DCP (mm/blow) | CBR (%) |
|-----------------|-----------|---------------|---------|
| Pit 3 DCP LW B1 | Clay | 15,48 | 13,58 |
| Pit 3 DCP LW B2 | | 17,62 | 15,61 |
| Pit 3 DCP LW B3 | | 17,67 | 18,70 |
| Pit 3 DCP LW B4 | | 12,67 | 22,88 |
| Pit 3 DCP LW A1 | Coal | 3,46 | 72,68 |
| Pit 3 DCP LW A2 | | 3,10 | 140,47 |
| Pit 3 DCP LW A3 | | 3,38 | 98,60 |

Table 3. Bearing Capacity Result Based On DCP Test

| Sample Code | Lithology | Bearing Capacity (kg/cm ²) |
|-----------------|------------|--|
| Pit 2 DCP LW B1 | Sandy Clay | 5,50 |
| Pit 2 DCP LW B2 | | 7,47 |
| Pit 2 DCP LW B3 | | 5,60 |
| Pit 2 DCP LW B4 | | 9,22 |
| Pit 3 DCP LW B1 | Clay | 6,60 |
| Pit 3 DCP LW B2 | | 6,87 |
| Pit 3 DCP LW B3 | | 7,21 |
| Pit 3 DCP LW B4 | | 7,59 |
| Pit 2 DCP LW A1 | Coal | 10,23 |
| Pit 2 DCP LW A2 | | 10,48 |
| Pit 2 DCP LW A3 | | 9,98 |
| Pit 3 DCP LW A1 | | 9,68 |
| Pit 3 DCP LW A2 | | 10,84 |
| Pit 3 DCP LW A3 | | 10,25 |

CBR Test Data

Samples for CBR test comes from DCP testing points. The first stage is to do the CBR test with sample preparation. Preparation done for make uniform grain size. Next phase, is doing standar proctor test to determine optimum moisture content of material. The optimum moisture content add to sample for next preparation phase. Further, soaking sample in the mold up to 96 hours to get the weakest condition. CBR test result can be seen in Table 4 and Table 5. Bearing capacity value based on DCP test result using USAE formula (see equation 5) can be seen in Table 6.

Table 4 Pit 2 Material CBR Test Result

| Sample Code | Lithology | CBR (100% ydmax) | CBR (95% ydmax) |
|-----------------|------------|------------------|-----------------|
| Pit 2 DCP LW B1 | Sandy Clay | 1,98 | 1,5 |
| Pit 2 DCP LW B2 | | 2,12 | 0,59 |
| Pit 2 DCP LW B3 | | 1,69 | 1,38 |
| Pit 2 DCP LW B4 | | 1,79 | 1,18 |
| Pit 2 DCP LW A1 | Coal | 8,82 | 6,7 |
| Pit 2 DCP LW A2 | | 5,59 | 4,12 |
| Pit 2 DCP LW A3 | | 9,51 | 6,51 |

Table 5. Pit 3 Material CBR Test Result

| Sample Code | Lithology | CBR Lab (100% γ_{dmax}) | CBR Lab (95% γ_{dmax}) |
|-----------------|-----------|---------------------------------|--------------------------------|
| Pit 3 DCP LW B1 | Clay | 1,55 | 1,15 |
| Pit 3 DCP LW B2 | | 1,59 | 0,86 |
| Pit 3 DCP LW B3 | | 1,2 | 0,82 |
| Pit 3 DCP LW B4 | | 0,91 | 0,61 |
| Pit 3 DCP LW A1 | Coal | 7,68 | 6,6 |
| Pit 3 DCP LW A2 | | 6,4 | 4,36 |
| Pit 3 DCP LW A3 | | 6,92 | 3,9 |

Table 6. Bearing Capacity Result Based On CBR Test

| Sample Code | Lithology | Bearing Capacity (kg/cm ²) |
|-----------------|------------|--|
| Pit 2 DCP LW B1 | Sandy Clay | 2,43 |
| Pit 2 DCP LW B2 | | 0,67 |
| Pit 2 DCP LW B3 | | 2,27 |
| Pit 2 DCP LW B4 | | 1,98 |
| Pit 3 DCP LW B1 | Clay | 1,93 |
| Pit 3 DCP LW B2 | | 1,38 |
| Pit 3 DCP LW B3 | | 1,24 |
| Pit 3 DCP LW B4 | | 0,73 |
| Pit 2 DCP LW A1 | Coal | 5,27 |
| Pit 2 DCP LW A2 | | 4,35 |
| Pit 2 DCP LW A3 | | 5,21 |
| Pit 3 DCP LW A1 | | 5,24 |
| Pit 3 DCP LW A2 | | 4,45 |
| Pit 3 DCP LW A3 | | 4,24 |

Bearing Capacity Correlation

From Table 3 and Table 6 has been obtained values of bearing capacity value from DCP and CBR test results. Furthermore, to find the relationship between the two tests, then conducted a simple linear regression correlation analysis. The analysis is done based on the type of material and not distinguish sample location. Correlation result using Ms. Excel scatter diagram can be seen in Figure 3, 4 and 5.

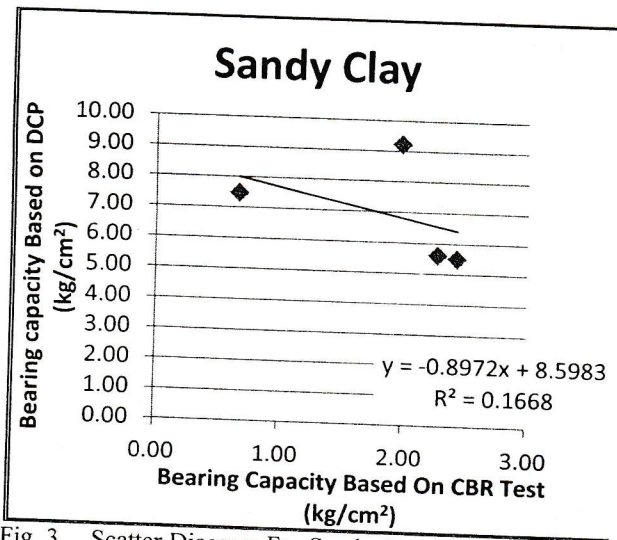


Fig. 3. Scatter Diagram For Sandy Clay

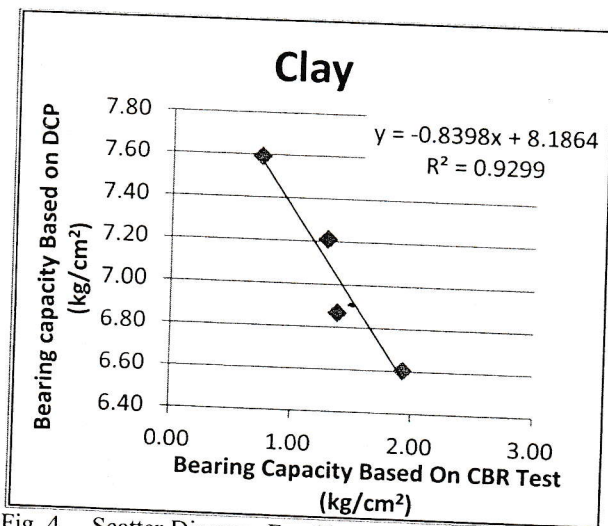


Fig. 4. Scatter Diagram For Clay

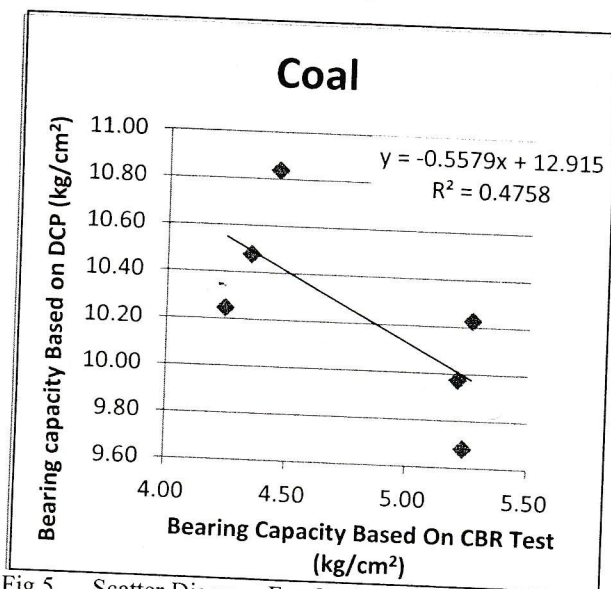


Fig. 5. Scatter Diagram For Coal

Correlation is done by looking at the actual test condition. DCP test is used as dependent variable. That

was done because DCP test performed directly on the field, so it would be more represent the actual conditions in field.

From the test above, DCP test was held in solid form material in field. Then CBR test was held in the weakest condition of loose materials (soaked). From the different testing condition, obtained insitu test result is more than laboratory test result.

Of correlation results using diagrams transmit and simple linear regression, it was found that more clay material has a strong correlation. It is characterized by a correlation coefficient (r^2) of 0.992. Then, for coal and sandy clay have correlation coefficient (r^2) < 0.5. It happens that the suitability test DCP and CBR will get better results if the grain size of the material is relatively uniform (Christady, 2010). In this study, clay have uniform grain size than sandy clay and coal material, mean clay having the highest coefficient correlation among all.

Yoder and Witzak (1975) in Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures Appendix CC-1 Correlation of CBR Values with Soil Index Properties (2001) have been approached as CBR value for several materials. The test result in comparasion with (or within) (??)this study can be seen at Figure 6.

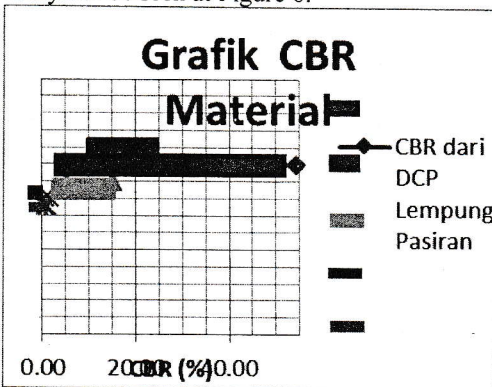


Fig 6. Comparasion of CBR Value

Figure 6 shows that unsoaked CBR for material clay CL (green bar) that held by Yoder and Witzak (1975) close to CBR value of Clay in this study (red bar). From this result could be concluded that there is a strong relationship between CBR from laboratory test and CBR value based on DCP test in the same testing condition.

Mechanical Recommendation

After performing correlation values, obtained the samlest bearing capacity value based on two study For more through application design, CBR test performed on the weakest possible condition in the field (Christady, 2010). In designing the use of carrying capacity in Indonesia using graph SKBI 2.3.26.1987 in Perencanaan Tebal Perkerasan Lentur Jalan Raya dengan Metode Analisa Komponen (1987).

On the graph that there is a minimum carrying capacity of 1 kg/cm². Therefore, the determination of mining equipment to use the value of CBR test results with a

minimum value of the bearing capacity of 1 kg/cm². From the data in Table 6 obtained a minimum bearing capacity used at 1.24 kg/cm² (124 kPa). Mining equipment that can be used by PT SEM can be seen in Table 7.

Table 7. Mining Equipment Based on Bearing Capacity

| Equipment | Brand | Type | Ground Pressure (kPa) |
|-----------|-------------|-------------|-----------------------|
| Bulldozer | Caterpillar | D10 T | 116,2 |
| Bulldozer | Komatsu | D275A-5R | 109 |
| Excavator | Caterpillar | 385C L | 117,6 |
| Excavator | Komatsu | PC 800SE-8 | 121,61 |
| Excavator | Volvo | EC 700NB LC | 100,1 |

CONCLUSION

From this result of this study, it is noted that:

1. DCP and CBR test more optimal when used on materials with uniform grain size.
2. Bearing capacity value of CBR test result in certain conditions is smaller than DCP test.
3. There are strong relation between CBR test and DCP test in the same condition of sample.
4. Minimum bearing capacity used for recommendation is 124 kPa.

ACKNOWLEDGEMENT

Author would like to thanks Mineral Coal and Studio especially Arif Akhyat Haryanto for collecting sample and all of PT. Senamas Energiindo Mineral for the cooperation.

REFERENCES

1. Harry Christady Hardiyatmo, 2010, *Perancangan Perkerasan Jalan dan Penyelidikan Tanah*, Gadjah Mada University Press, Yogyakarta.
2. J. Supranto, 2000, *Statistik : Teori Dan Aplikasi*, Erlangga, Jakarta.
3. Terzaghi, Karl, 1996, *Soil Mechanics for Engineering Practices*, John Wiley and Sons Inc, New York.
4. _____, American Standard Testing Material D1883 for Laboratory CBR Test.
5. _____, 1987 *Perencanaan Tebal Perkerasan Lentur Jalan Raya dengan Metode Analisa Komponen*, Yayasan Badan Penerbit PU, Departemen Pekerjaan Umum.
6. _____, 2001, *Guide for Mechanistic-Empirical Design Of New And Rehabilitated Pavement Structures Appendix CC-1 Correlation of CBR Values With Soil Index Properties*. ARA, Inc. ERES Division.
7. _____, 2012, *Komatsu Application Handbook ed 31*.
8. _____, 2012, *Catterpillar Performance Handbook ed 40*.