POROSITY AND DENSITY ANALYSIS USING REGRESSION TESTS AND ANALYSIS OF ELASTICITY MODULES

As Determining the Type of Rock on Rock Forest Area Maros District is Applied for Making Cement Raw Materials

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Abstract: A polynomial regression test was performed to find out the relationship of density to porosity. With a regression test, the correlation between density and porosity can be known to looking for the right order. The right order to use is order 3 which has the value of y= -0,0002x^3 + 0,0102x^2 - 0,1104x + 3,3713 with a value of R2 = 0.78. Based on the porosity, density, and scale values it can be concluded that in this area there are types of limestone. Besides, the Modulus of Elasticity calculation has been carried out to determine the distribution of rock types found in the Karst area of Batu Maros Forest. The average rock found in the Maros Forest area is limestone as evidenced by the compatibility of the Modulus of Elasticity in the table of rock types and the modulus of elasticity that is equal to 14.78779916, 16.27819781 and 20.79792362 and the rest is a gypsum stone type so that the prospect can be used as raw material for making cement.

Keywords: Density, Modulus of Elasticity, Porosity, Regression.

Introduction

1.1 Introduction

Each rock has different properties ranging from physical properties, mechanical properties, and chemical properties. Physical properties are properties possessed by a rock that can be seen directly. When talking about the physical properties of rocks certainly cannot be separated from porosity and density. The relationship between porosity and density has an important position. Mechanical properties are properties possessed by rocks due to an external force acting on the rock. At this time we take one example of the mechanical properties of rocks, namely modulus of elasticity. This paper refers to a paper entitled 'Analysis of Physical Properties and Mechanical Properties of Maros Karst Rocks' in that paper only lists the values of density and porosity in rocks in the Maros Karst Area. The previous paper also explained that the correlation between density and porosity was inversely proportional to looking at data only, not from proof of calculation. From the mechanical properties test data, we can calculate stress and strain so that we can find the results of the modulus of elasticity so that the data we match is accurate based on the table of density, porosity, scale, and modulus of elasticity. After finding what rock is in the area, we can analyze that the area taken from the data can be used as a place for taking raw materials for making cement.

1.2 Basic Theory

1.2.1 Porosity

Porosity is the ratio between the volume of space contained in rocks in the form of pores to the overall rock volume, usually expressed in fractions. The size of the porosity of rock will determine the reservoir fluid storage capacity. The range of porosity values is between 0 and 1 or as a percentage between 0-100%. Porosity depends on material type, material size, pore distribution, cementation, diagenetic history, and composition Mathematically porosity can be expressed as:

$$\varphi = \frac{V_p}{V} = 1 - \frac{V_m}{V}$$

where V_m is the volume of solid rock.

1.2.2 Density

Density is a value that indicates the magnitude of the ratio between the density of objects with the volume of the object, the density of an object is fixed meaning that if the size of the object is changed then the density is fixed, this is caused by the mass of the object and the increase in the volume of the object is followed linearly with an increase in volume objects or mass of objects. To determine the mass of an object can be done by weighing the object with an appropriate scale, such as Ohaus balance or the other. (Halliday,1991)

$$\rho = \frac{m}{v}$$

Note: ρ = porosity

m = mass

v = volume

1.2.3 Polynomial Regression

Polynomial Regression is a linear regression model that is formed by adding up the effect of each explanatory variable raised to the mth order. Polynomial regression models up to the m - order in general (Drapper&Smith, 1992)

$$y_j = \beta_0 + \beta_1 x_j + \beta_2 x_j^2 + \cdots + \beta_p x_j^p + \varepsilon_j$$

note:

$\beta_0 = Parameter\ Intersep$

$\beta_k = Coef\ parameter\ x_j^p, where\ k = 1,2,\ldots,p$
$\varepsilon_j = Error\ random\ to - j, where\ j = 1,2,\ldots,n$
$y_i = Response\ variable\ to - j\ where\ j = 1,2,..,n$
$x_j = predictor\ variable\ to - j, where j = 1,2,..,n$

1.2.4 R Square (R^2)

R Square is known as the Multiple Determination Coefficient. Explanation of Linear Regression Test or interpolation results here will explain what exactly R square is. The coefficient of multiple determination, its function is to measure the goodness of fit of the regression equation:

$$R^2 = 1 - \frac{SS\ Eror}{SS\ Total} = 1 - \frac{\sum(y_i - \hat{y}_i)^2}{\sum(y_i - \bar{y})^2}$$

Note :

$y_i = response\ observation\ to\ i$
$\bar{y} = mean$
$\hat{y}_i = response\ forecast\ to\ i$

i.e. gives the proportion or percentage of the total variation in the dependent variable explained by the independent variable. The value of R ² lies between 0 - 1, and the suitability of the model is said to be better if R ² gets closer to 1. A high R square value is a

good model value criterion for predicting data.

1.2.5 Modulus of Elasticity

Modulus of elasticity or often also called Modulus Young is a comparison between stress and axial strain in elastic deformation so that the modulus of elasticity has a tendency for a material to change shape and return to its original shape when given a load. (SNI 2826-2008). The equation to get the modulus of elasticity is:

$$e = \frac{\frac{F}{A}}{\frac{\Delta X}{A}}$$

where:

e = young's modulus

F = the tension in the wire

A = cross-sectional area

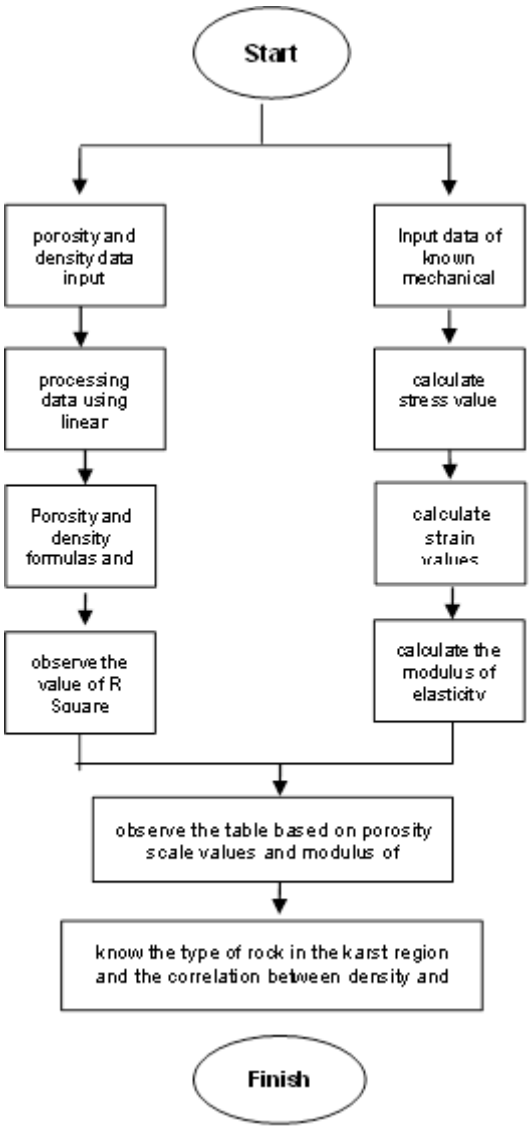
$\Delta X = F_1 - F_0$

Materials and Methods

2.1 Methodology

In this paper, we discuss the correlation between the porosity of a rock and its density. Using linear regression is a method that can be done to get the correlation formula for these two parameters. This paper uses secondary data obtained from a paper entitled 'Analysis of Physical Properties and Mechanical Properties of Maros Karst Rocks'. Secondary data in curve fitting using polynomial regression with various orders, namely 2, 3, and 4. From the regression curve, the equation of the regression curve is generated and the R^2 curve value. The value of R^2 is compared between curves and selected the closest value to 1. The more the R^2 value is close to 1, the more suitable the curve is in representing the correlation of porosity data with density. The threshold value of R^2 that we have determined is 1. To determine what type of rock is in the Karst area of the Stone Forest districts Maros, Modulus Elasticity calculation is needed which begins with the calculation of stress and strain from the data that is already available. After getting the Modulus of Elasticity calculation, we can find out what rocks are in the area based on the values that have been matched with the table.

2.2 Flowchart



Result and Discussion

3.1 Data Analysis

The following is a paper data from the measurement of the density and porosity of karst rocks in the Batu Maros Forest.

Sample	Porosity (%)	Skala (%)	Density (gr/cm^3)
119°60'20"BT4° 92'25"LS	5.60	5-50	3.21
119°60'14"BT4° 92'31"LS	4.30	0-5	2.96
119°59'95"BT4° 92'42"LS	8.30	5-50	2.96
119°60'06"BT4° 92'29"LS	29.55	5-50	3.31
119°60'25"BT4° 92'38"LS	33.9	5-50	2.72

3.2 Discussion

The curve fitting data method has been obtained from a paper entitled 'Analysis of Physical Properties and Mechanical Properties of Maros Karst Rocks' to get the appropriate order, so that it produces the right model to determine the value of unknown physical parameters. The previous paper only discussed the calculation of porosity and density without knowing the correlation between the two parameters. The correlation between the two parameters can be known by using the regression test method and finding the right order. The right order is R^2, the result is close to 1. Because if R^2 is close to 1 error, the data obtained is very low. The order used in this paper is Order 3 which has a value of $y = -0.0002x^3+0.0102x^2-0.1104x + 3.3713$ with a value of $R^2 = 0.78$ because the value is closest to 1 with a graph showing the corresponding porosity and density relationships. Order 1 is not used because it cannot show a constant relationship (R^2 values below 0). Order 2 is worth y =-

$0.0027x^2$ +0.0979x+2.571 with a value of R^2 = 0.4019 but the value of R^2 in this order is still not close to 1. Order 4 is worth $y = -0.0001x^4 + 0.0084x^3 - 0.1992x^2 + 1.5967x - 0.8546$ with a value of $R^2 = 1$, even though the polynomial regression chart of this order shows a relationship that does not correspond to porosity and density.

Previous paper discusses the mechanical properties of rock pressures in the Karst of Batu Maros Forest. From the data that has been obtained based on the calculation of scale, porosity, and density shows that area analyzed that there was limestone karstified because it is in the range of 5-50% and there are also types of limestone and dolomite limestone. However, when we analyzed using the modulus of elasticity there was 1 sample that was not limestone but showed the result that 1 sample was gypsum. The rocks that have been analyzed in this area can be used as raw material for making cement, although further research needs to be carried out on their chemical composition in terms of the value of the chemical elements CaO and MgO.

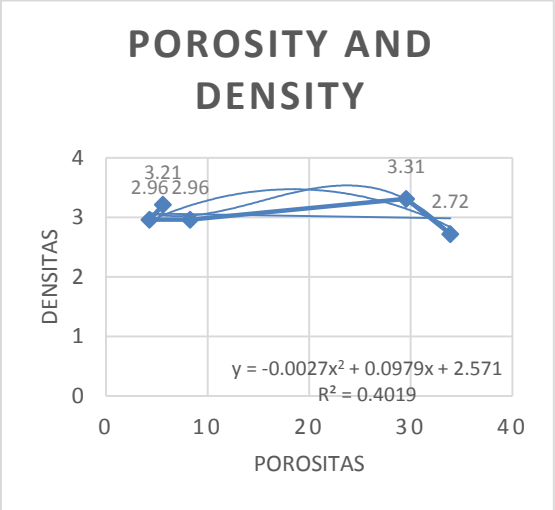


Figure 3.1 : Polynomial Regression Chart of Order 2 Porosity to Density

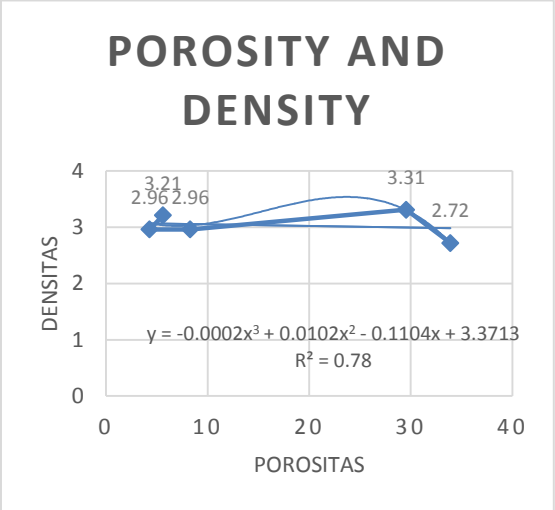


Figure 3.2 : Polynomial Regression Chart of Order 3 Porosity to Density

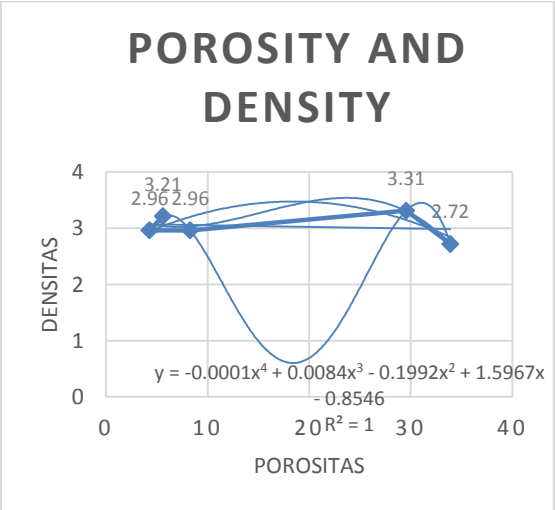


Figure 3.3 : Polynomial Regression Chart of Order 4 Porosity to Density

Conclusion

The conclusions obtained are

1. Density and porosity are inversely proportional, evidenced by the relationship graph density and porosity that have been obtained through regression tests using the equation $y = -0.0002x^3+0.0102x^2-0.1104x + 3.3713$ with a value of $R^2 = 0.78$
2. The average rock in the Maros Stone Forest area is limestone, as evidenced by the calculation of density, porosity, scale, and modulus of elasticity, although in some tests found the results of limestone, dolomite, and gypsum.
3. Limestone Resources can be used as raw material for making cement because after the calculation is also done there are limestone and gypsum which is usually used for cement-making mixtures.

References

[1] Arsyad, Hermawan, dkk. Analisis Ketersediaan Air Sungai Bawah Tanah dan Pemanfaatan Berkelanjutan di Kawasan Karst Maros Sulawesi Selatan. Journal Manusia Dan Lingkungan, 21(1), 8-14.

[2] Draper, N.R. and Smith, H. 1998. Applied Regression Analysis,Three Edition. John Wiley and sons, Inc. New York.

[3] Ferdinand P.; Johnston, E. Russell; Dewolf, John; Mazurek, David (2009). Mechanics of Materials. McGraw Hill. hlm. 56. ISBN 978-0-07-015389-9.

[4] Putra, Arahman Panji, dkk. 2017. Studi Potensial Sumberdaya Batu Gamping Sebagai Bahan Baku Pembuatan Semen di Kecamatan Buay Sandang Aji Kabupaten Ogan Komering Ulu Selatan.1(3), ISSN 2549-1008.

[5] Rosari, Andi Anita, dkk. 2017. Analisis Sifat Fisis dan Sifat Mekanik Batuan Karst Maros. Jurnal Sains dan Pendidikan Fisika, 13, 276-281.

[6] Serway, R. A. 1986, Physics for Scientist and engineering with Modern Physics, New york: Saunders College Publishing.

[7] Tipler, P. A., 1998, Fisika untuk Sains dan Teknik Jilid I (Terjemahan), Jakarta: Penerbit Erlangga Jilid I.