THE EFFECT OF DOLOMITE AS LIGHTWEIGHT AGREGATE'S SUBSTITUTE TO THE CONCRETE'S COMPRESSIVE STRENGTH

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ABSTRACT

Indonesia is the country which has many natural resources that can be utilized in everyday life. One of the uses of natural resources is as a construction material. Human life cannot be separated from the construction field, because house is one of the basic human needs. Dolomite is a natural resource, which is generally used by many people as a mixture of cement, bricks, and soil fertilizer. However further research in the use of dolomite as a natural resource is needed, so that it is more useful and save. Dolomite can be used as a substitute for sand in concrete construction. Therefore, this research is conducted on the use of the dolomite material in the construction of concrete. Concrete specimens were made with a mixture proportion of dolomite as a replacement of sand. Then the compressive strength test is conducted. From these tests, it can be seen the influence of dolomite in the concrete mix and the percentage content of dolomite that can be used instead of sand.

Keywords: compressive strength, dolomite, substitute for sand

INTRODUCTION

Dolomite is widely available in Indonesia. In Bangkalan, dolomite's spread in one kilometer east of Socah. Reserves in the form of raw resources including Pliocene age Kalibeng formation, white color, slightly lightweight, nest, is under limestone with the content of MgO = 9,32-20,92%. (Pusat Penelitian dan Pengembangan Teknologi Mineral dan Batubara, 2005)

Dolomite is commonly used by people as cement's mixture, bricks, and fertilizer to loosing soil. Special for Bangkalan area which keeps a large dolomite's mine potency, dolomite is only used as *tanah urug* and *kumbung* stone's production. Until now there is no scientific data that shows the influence of dolomite when used as aggregate in concrete production. Therefore, the use of dolomite as concrete's constituent materials is still need to be reviewed further. Especially in terms of the effect of the use of dolomite to compressive strength, which is become concrete's main structural function.

The aim of this research is to discuss the concrete's compressive strength as a structural material, particularly the effect of adding dolomite variation in the substitution of fine aggregate on concrete's compressive strength.

REVIEW OF RELATED LITERATURE

Aggregate fills 60-80% of concrete's volume. Therefore, aggregate's chemical, physical, and mechanical characteristics used in the mixture impact to concrete's characteristics obtained (such as compressive strength, strength, durability, weight, production cost, etc.).

Lightweight aggregate is sand-formed filler. Its size varies between size no.4 and no. 100 in U.S. standard sieve. A good lightweight aggregate should be free of organic materials, clay, smaller particle than filter number 100 or other material which could damage the concrete's mixture. Variations of size in the mixture should have a good gradation, which is compatible with ASTM's sieve analysis standard.

Aggregate is a mineral particle which is functioned as filler in mortar mixture (stir) and concrete or defined as material which is used as filler, along with adhesive material and form a hard mass, solid, which is called as concrete. In addition, as described above, the main function of lightweight aggregate is as filler material between coarse aggregate, so the bond becomes stronger.

Dolomite is classified as carbonate minerals. Dolomite's pure mineral theoretically contains 45,6% $MgCO_3$ or 21,9% MgO and 54,3% $CaCO_3$ or 30,4% CaO. Dolomite mineral's chemical formula can be written as $CaCO_3.MgCO_3$, $CaMg(CO_3)_2$ or $Ca_xMg_{1-x}CO_3$, with x score is smaller than one. Dolomite in nature is rarely pure, because generally this material is always together with limestone, quartz, chert, pyrite and clay. In dolomite's mineral there is also polluter especially iron ions.

Dolomite is a limestone which is changed because of sea water (Ca with a little or lots of $MgCO_3$) (*Soemargono, 1974:11*) and if it is contained Fe, it is easily weathered. H = 4 (*Soemargono, 1974:7*). H = 4 is the 4^{th} scale sequence of 10 mineral's hardness degree scale sequence.

Dolomite's wide spread is in North Sumatera, West Sumatera, Mid Java, East Java, Madura, and Papua. Actually in some region there is dolomite potency, but the number is relatively small and only in the form of lenses in limestone deposits. (Madiapoera,1990)

RESEARCH METHODS

Research Variable

The independent variable of this research is normal concrete, variation of dolomite's addition 0%, 25%, 75%, 100% of sand substitution. While the dependent variable is concrete's porosity and elasticity modulus.

Specimen Identification

The specimens were casted after knowing dolomite's mixture proportion as additive material in the mixture.

Analysis of Raw Material Used

In this research dolomite size was form from rocks to finest, with the following progress:

- Taking dolomite from mine in Jeddih Village, Socah, Bangkalan District.
- Destruction of dolomite rock to sand-sized powders
- Dolomite's powder's screening to select more detail the destruction process's result. In this step the dolomite used is powder which passed filter number 100'.

Table 1. Total specimens

Test	Speci-men	Total Specimen for each Dolomite Percentage as Sand's Substitute			
		0%	25%	75%	100%
Compre-ssive Strength	Concrete	5	5	5	5

Raw Material Test

Raw material's test that will be conducted is:

- **Dolomite**

Dolomite's material test consists of characteristics as follows:

1. Testing dolomite's density and water absorption
2. Dolomite's content weight checking
3. Dolomite's gradation checking

- **Sand**

The sand is tested as dolomite from Malang, East Java

Compressive Strength Test on Specimens

The steps to test concrete's compressive strength, which is conducted at 28 days age, are as follow:

1. Take specimen from soaking tub, clean of dirt with a fabric moisturizer.
2. Decide specimen's weight and size.
3. Put specimen on machine centrically.
4. Run the specimen by adding constant load based on 2 to 4 kg/cm^2 per second.
5. Do loading until the specimen's destroyed and note the maximum load happened in the test.

Concrete's compressive strength was calculated with the following calculation:

$$\sigma_c = P/A \ (\text{kg/cm}^2)$$

Where:

P = Maximum load (kg)

A = Specimen's cross-sectional area (cm^2)

Analysis Method

Statistical analysis aims to find the effect of dolomite use as sand's substitute to concrete's compressive strength. The analysis process is as follows:

1. **Normality Test**

Normality test is conducted to know the variables' scores gained from normally distributed or nearly normal observed data. One of the methods in analyzing normally distributed population is Kolmogorov-Smirnov goodness Of Fit Test. The indicators in null hypothesis (Ho)'s acceptance or rejection is by looking at probability level. If P_{count} is bigger than 5%, is can be assumed that H_0 is accepted (Normally distributed population), and vice versa. If the data obtained is normal or near-normal distributed then followed by analysis of variance.

2. **Hypothesis Test**

The variant analysis (ANOVA) is one way-ANOVA with control treatment. This is done to determine differences in the stability of the asphalt variation's condition in HRS mixture of each scenario.

If assumed that the second treatment as treatment number 1,2,3,… and so on with average score μ_1, μ_2, μ_3, … and so on, while the one without acid mixture with the average score = μ_0 as control, then the hypothesis can be written:

H_0 : $\mu_0 = \mu_1 = \mu_2 = \mu_3$ … and so on

H_1 : $\mu_0 < \mu_1 < \mu_2 < \mu_3$ … and so on

The ANOVA used to test the null hypothesis is also commonly called the F test. F score is obtained from the average sum of squares between groups divided by the average number of squares in the group. The statistical formulation is as follow:

$$Z = \mu + \beta_j + \beta_{ij} + \xi_{ij}$$

Where :

μ = average score

β_i = i- Dolomite's level's effect

$(\beta)_{ij}$ = variant's effect

ε_{ij} = error

Statistical hypotheis tested are:

$H_0 : \mu\alpha_1 = \mu\alpha_2 = \ldots\ldots = \mu\alpha_i$

H_1 : at least a pair of $\mu\alpha_i$ which is not the same as $\neq 0$

$H_0 : \mu\beta_1 = \mu\beta_2 = \ldots\ldots = \mu\beta_j$

H_1 : at least a pair of $\mu\beta_j$ which is not the same $\neq 0$

where :

H_0 = Null hypothesis, which states that there is no effect of dolomite's level's to sand mixture parameter in concrete production.

H_1 = Alternative hypothesis, which states that there is effect of dolomite's level's factor to sand mixture parameter in concrete production.

The indicator of whether the hypothesis ias accepted or rejected is if $F_{count} > F_{table}$ maka H_0 is rejected, and vice versa, if $F_{count} < F_{table}$, then H_0 is accepted. Moreover, it can be seen from the data significance level. if $signification_{count} > 0,05$, then H_0 is accepted. In other hand, if signification $_{count} < 0,05$, then H_0 is rejected.

3. Regression Analysis

Regression analysis is used to know the relation of two or more numerical variables. In this research, the variables of regression analysis's formula consist of one dependent variable and two independent variables, therefore double regression formula is chosen with the general formula as follow:

$$Zi = b_0 + b_1 x + b_3 (x)^2$$

Where:

Z = measured score (respond variable)

X = Dolomite's level's variation (explanatory variable)

b_0, b_1, b_2, dan b_3 = parameters sought

4. Speciment test for Two Independent Samples

This test is conducted to compare averages of two groups which is not connected one to another.

Data used in this analysis is commonly quantitative, with assumption that data is normally distributed and few total sample. Indicator whether Null hypothesis (H_0) is accpeted or rejected is by looking at t_{count} score and probabillity. If $t_{count} > t_{table}$ and probabillity < 5%, then H_0 is rejected (actually different).

RESULTS AND DISCUSSION

Material Test's Result

1. Density and Lightweight-Coarse Aggregate's Absorption Test

Density test and lightweight-coarse aggregate's absorption test are needed to determine the values of bulk's density, saturated surface dry's density, apparent density and absorption of coarse aggregate and lightweight aggregate. **Table 2** is the result obtained in density and absorption of coarse aggregate and lightweight aggregate's test.

Based on lightweight and coarse aggregate's unit weight checking, then concrete's aggregate's unit weight analysis can be seen in **Table 3**.

Table 2. Data calculation of density and absorption of coarse aggregate and lightweight aggregate's test

	Lightweight aggregate	Coarse aggregate
Bulk Spesific Grafity	2.217	3.261
Bulk Spesific Grafity Saturated Surface Dry	2.357	3.437
Apparent Spesific Gravity	2.584	3.958
Absorption (%)	6.296	5.385

Table 3. Data Calculation of density test

Aggregate	Density	
	Rodded	Shoveled
Coarse Aggregate	4470	4132
Dolomite	3590.8	3187.8
Lightweight Aggregate	4075.8	3822

Table 4. Moisture calculation data

Moisture	
Lightweight aggregate (%)	3.284
Dolomite (%)	17.1598
Coarse aggregate (%)	0.9335

Table 5. Specific gravity test's calculation data and phyropilit absorption.

Bulk Specific Gravity	1.8
Bulk Specific Gravity Saturated Surface Dry	2.074
Apparent Specific Gravity	2.483
Absorption (%)	15.261

Table 6. Dolomite inquiries for 1 brick 15/15/15

Dolomite Level (%)	Concrete 15/15/15	
	Need	Need
	filler (kg)	Dolomite (kg)
0	3.505	0
25	3.505	0.87634
75	3.505	2.629

2. Aggregate's Moisture Test

Moisture test of lightweight and coarse aggregate is needed to gain water percentage which is contained in lightweight and coarse aggregate. **Table 4** shows the result in raw material's test.

3. Dolomite Test

Dolomite's characteristics data gained from pyropilite test, which influence the specimen's result, as in **Table 5. Table 5** Specific gravity test's calculation data and phyropilit absorption.

Dolomite Mixture Material

Based on concrete's mix design's result, amount of dolomite needed for 1 brick of 15/15/15 and the weight of 1.455 kg can be seen in **Table 6.**

Concrete Testing

Compressive strength's testing in dolomite concrete is conducted through specimen with the dimension is 15 x 15 x 15 cm and the total specimen is 20, which is divided into 5 for each dolomite's variations.

1. Concrete Compressive Strength Testing

Concrete elasticity modulus is done by using concrete's compressive strength test plus dial gauge to find concrete's vertical strain. The result of concrete's compressive strength is shown in **Table 7.**

One-way varian analysis of concrete's compressive strength test by using Anova method can be seen in **Table 8**.

Table 7. Dolomite concrete compressive strength

Compressive Strength			
0% dolomite 100% sand	25% dolomite 75% sand	75% dolomite 25% sand	100% dolomite 0% sand
287.786	295.037	182.189	144.572853
263.313	266.032	217.539	130.9766599
324.949	296.850	180.376	149.1049173
288.692	285.520	194.426	142.3068208
295.944	244.278	208.475	147.745298

Table 8. One-way variant analysis with Anova Method

Sumber Keragaman	JK	DB	KT	f_{hitung}	F_{table}
Perlakuan	73935.3	3	2465.1	75.9	3.9
Galat	5196.6	16	324.8		
Total	79131.9	19			

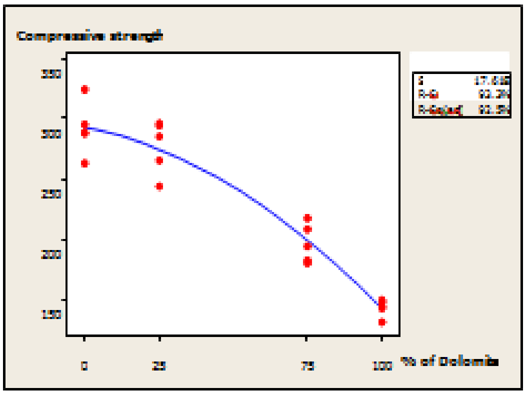

Figure 1. Dolomite content and concrete compressive strength

Statistical calculation analysis by using ANOVA method based on the table above, found that for dolomite concrete's compressive strength with variation of dolomite's addition as lightweight aggregate substitution, $F_{count} > F_{Table}$. This shows that Ho is rejected so it can be concluded that there is significant effect between dolomite's level additions to dolomite's concrete's compressive strength.

2. Regression Analysis of Dolomite's Effect to Concrete's Compressive Strength

Regression analysis is one of methods to determine cause-effect relation between one variable with another. In this research, regression analysis is used to find the relation of dolomite's addition's percentage to concrete's compressive strength by using polynomial regression graph.

Relation's graph which is happened between explanatory variable (dolomite's percentage) and respond variable (concrete's compressive strength) to 20 concrete samples can be seen in **Figure 1.**

Figure 1 explains the relation of dolomite's level addition to concrete's compressive strength. The polinomial line above can shows the highest concrete's compressive strength for ech variation of dolomite's level in the specimen.

For the relation of dolomite's level's addition to concrete's compressive strength, polynomial regresion's equation which is gained is

$$y = 293.4 - 0.4756\,x - 0.01042x^2\ .$$

It shows that 25% dolomite's level addition is the closest to the maximum of the polynomial line above than dolomite addition in 75% and 100%. The graph also explains that maximum compressive strength is in the normal concrete type, however 25% dolomite's percentage has the closests strength with normal concrete.

3. Discussion of Dolomite Concrete's Compressive Strength

Statistical calculation shows that by using dolomite, the result of concrete's compressive strength is decreasing. The influence of the use of dolomite to the concrete's compressive strength can be seen from the test results for each composition. Dolomites' compositions' compressive strength's scores if compared to normal concrete's compressive strength are:

- Normal concrete (variation 0 % of dolomite's addition) obtains average compressive strength **292.1369 kg/cm^2**.
- Concrete with 25% dolomite's addition obtains average compressive strength **277.5436 kg/cm^2**, not higher than the compressive strength of normal concrete.

- Concrete with 75% dolomite's addition obtains average compressive strength **196.6010 kg/cm^2**, not higher than the compressive strength of normal concrete.
- Concrete with 100% dolomite's addition variation obtains average compressive strength **142.9413 kg/cm^2**, not higher than the compressive strength of normal concrete.

Based on the analysis above it can be found that the compressive strength of dolomite concrete decreased most of variation of dolomite's percentage as lightweight aggregate's substitution in concrete, so dolomite addition in concrete affects its compressive strength.

This shows that in the initial hypothesis where dolomite's usage as lightweight aggregate's substitution is not affect to concrete's compressive strength parameter is proven. Because dolomite's addition to concrete will only decrease concrete's compressive strength, but in other viewpoint dolomite concrete tends to lead to economic value and utilization of mining waste of white stone in Bangkalan, Madura.

4. Percentage of Dolomite's Effect to Dolomite Concrete's Compressive Strength

Based on the compressive strength's score which is produced in every dolomite's addition variables, the percentage of compressive strength score changing's effect to normal concrete compressive strength of each variants can be found. The percentage of compressive strength's effect can be seen in **Table 9.**

Table 9. Percentage of compressive strength's effect

Dolomite level	Average compressive strength (kg/cm²)	Percentage of effect (%)
0%	292.137	0
25%	277.544	-5.258
75%	196.601	-48.594
100%	142.941	-104.375

Table 9 shows that by using 25% dolomite's variation addition can reduce dolomite concrete's compressive strength to 5,258%, while 75% dolomite addition variation can reduce dolomite concrete's compressive strength to 48,5938%, and 100% phyropilite addition variation can reduce dolomite concrete's compressive strength to 104,3754%.

The result of analysis above shows initial hypothesis that there is optimum dolomite's level as lightweight aggregate's substitution, which is needed to produce concrete's mixture with maximum compressive strength parameter, is in 25% dolomite's addition variation. The data obtained should be consideration for the future research.

CONCLUSIONS

Based on research's result and analysis, the conclusion of this research is as follow:

1. The ANOVA test's result shows that the variation of dolomite's level as lightweight aggregate's substitute effect concrete's compressive strength's parameter
2. The polynomial regression analysis shows that dolomite's optimum level which is needed as lightweight aggregate's substitution to produce maximum compressive strength is 0 - 25% dolomite.

This research is still need improvement, therefore some suggestion as follows:

1. There should be further research of dolomite's addition when it is used as lightweight aggregate's substitute in concrete, because it is difficult to gain Lumajang sand in Bangkalan Madura area.
2. Concrete's forming material whether it is coarse or lightweight aggregate should be placed in closed area (not humid), because it would effects aggregate's moisture, which make it not compatible with material's criteria in *mix design.*
3. The pulverization process in concrete's casting should be done as good as possible because the process will affect concrete's rigidity level.

REFERENCES

SNI-3-0349-1989. Standar Nasional Indonesia (SNI) 03 – 0691-1996.

Tiurma Simbolon. 2009. *Pembuatan dan Karakteristik Batako Ringan yang Terbuat Dari Styrofoam Semen*. Sekolah Pasca Sarjana Universitas Sumatera Utara.

Yanuar Azis. 2012. Pengaruh Penggunaan Piropilit dan Variasi Jenis Semen Terhadap Kuat Tekan dan Porositas Batako. Fakultas Teknik Universitas Brawijaya.

Yulianto, E.Y. 2007. Pemanfaatan Limbah Batubara (*Bottom Ash*) sebagai Bata Beton Ditinjau dari Aspek Teknik dan Lingkungan.Tugas Akhir Sarjana, Jurusan Teknik Sipil, Universitas Brawijaya.