

# THE IMPACT AGGREGATE QUALITY MATERIAL AS A LINEAR REGRESSION STUDY ON MIXTURE CONCRETE

\*Ranti Hidayawanti<sup>1</sup>, Dicki Dian Purnama<sup>2</sup> Tommy Iduwin<sup>3</sup>, Supriadi Legino<sup>4</sup> and Fahdun Ibnu Wachid<sup>5</sup>

<sup>1,2,3</sup>Department of Civil Engineering, Sekolah Tinggi Teknik PLN, Indonesia; <sup>4</sup>Founder Tempat Olah Sampah Setempat, Sekolah Tinggi Teknik PLN, Indonesia, <sup>5</sup>PT. Pembangunan Jawa Bali, Indonesia

Corresponding Author; Received: 15 Oct. 2019, Revised: 18 Nov. 2019, Accepted: 12 Dec. 2019

**ABSTRACT:** Fine aggregate and coarse aggregate are important components in making concrete for light and structure concrete. These mixture concretes are one of the elements as structural component in building construction. Generally, this aggregate is easy to find both coarse and fine aggregates beside the aggregate can be used as a component on concrete in the building which needs strong support. The objectives of this study are adding mixture aggregate with compared to designed result (theory) mixture concrete by using the method of fine modulus and linear regression. Those two methods will be found out theoretically in optimizing certain components (economic). In order to get the presentation of aggregate and meet the requirement of standard quality concrete, are used the comparison of fine and coarse aggregate at 60% - 40%. The method that is used to pass the screening is fine modulus and the counting of mixture aggregate used statistic formula calculation which is regression linear method to find the percentage comparison between coarse and fine aggregate in designing of a mix that can be used in making concrete. By knowing the maximum aggregate limit, it is expected to find out the limitation aggregate of fine and coarse accurately so that the result of concrete that is used is better because the raw material is correct for the construction composition. From the test results for fine aggregate  $R^2 = 0.9444$  and coarse aggregates  $R^2 = 0.9581$  with linear regression formulation is and compressive strength shows the value of  $R^2 = 0.9627$ , then the strength of the relationship between variables can be expressed by the magnitude of the correlation coefficient value on the linear function.

*Keywords: Fine Aggregate, Coarse Aggregate, Fine Modulus, Concrete, Linear Regression*

## 1. INTRODUCTION

Aggregate is a basic material used in buildings ranging from the lowest structure to the uppermost structure, both as fine aggregates and coarse aggregates used in each mixture of concrete mixtures. It is commonly known that 70% of the building is concrete[1]. According to SNI 03-2847-2002, concrete is a material obtained by mixing Portland cement or other hydraulic cement, fine aggregates, coarse aggregates and water, with or without additives forming solid mass. The use of material from concrete can also be used with waste[2]. Besides that there are still many other uses of fine and rough aggregates in building use such as filling in building columns, making foundations and road infrastructure.

In determining and grouping the size and type of fine and coarse aggregates, it is important to note that the quality of the building blocks of building materials is suitable and ideal. For this reason, it is necessary to test the gradation in each aggregate to be used as a mixture.

The index used to show the fineness / coarseness of aggregate grains is MHB, and the factors that can influence the search for fine grain modulus (MHB) are the sieve size used and the size of aggregate grains[3], where the formulation is as follows :

$$w = \frac{k-c}{c-p} \times 100\% \quad (1)$$

w = Percentage of fine aggregate (sand) in the mixture

k = Fine modulus of coarse aggregate

p = Fine modulus of sand

c = Fine modulus mixture

Gradation can be said as smooth or rough modulus in an aggregate, this difference will affect the use of aggregate as a building material. All types of aggregates taken from the source must be processed before use. Washing and filtering is a processing process that must be carried out and has been required for its use.

In order to get gradations that are in accordance with the standard concrete mix, an experiment needs to be carried out then the results of the experiment will be processed. Data processing is done using linear regression formulations.

$$\hat{y} = a + bx \quad (2)$$

$\hat{y}$  = Estimate value of the dependent variable

a = Intersection point of the regression line on the y axis or the estimated value if x = 0

b = Gradient of the regression line (change in the estimated value per unit change in the value of x)

x = Free variable value

The formula of linear regression [4] is the data

taken based on the dependent and independent variables.  $R^2$  is the coefficient of determination (coefficient of multiple determination) of a regression model that can be defined, as follows :

$$R^2 = \frac{SSR}{SSTO} = 1 - \frac{SSE}{SSTO} \quad (3)$$

$$0 \leq R^2 \leq 1$$

The greater value of  $R^2$ , the better model used and the result  $R^2$  is the value of regression analysis while approaching 1 means the data can be used.

This study aims to determine the effect of aggregate grain size on compressive strength and modulus of elasticity of concrete. Compressive strength of concrete with a larger grain size has a lower compressive strength value than concrete with a smaller size. A good aggregate gradation and small aggregate size will be able to produce maximum density and minimum porosity.

$$f'_c = \frac{P}{A} \quad (4)$$

$f'_c$  = Value of Concrete Compressive Strength (MPa)

P = Compressive Force that occurs (N)

A = Test Surface Area (mm<sup>2</sup>)

## 2. MATERIALS

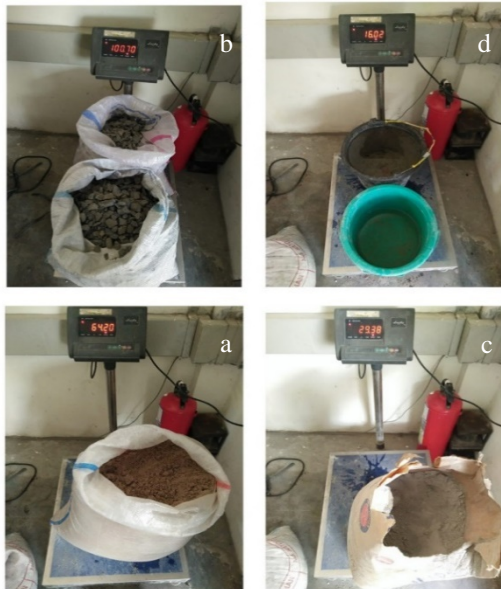


Fig. 1 Mix Design Laboratory

In the laboratory test the sample used are :

- Fine aggregates (Bangka Sand)
- Coarse aggregates
- Cement
- Water

Laboratory supporting equipment for the sample above are :

- Weight scale fine aggregate
- Trays
- Sieve shaker tools

- Sieve cleaning brush
- Sieve coarse aggregate
- Mini mix
- Compressive strength tools



Fig. 2 Supporting Equipment

## 3. METHODOLOGY

In order to get the quality of the uniformity of the concrete according to what is required, the implementation of concrete making must be done well and in accordance with the standard code procedures. Elaborate on test method used. The test results are implemented into statistical formulations with linear regression formulas. The stages in the design are: Analysis of fine aggregate and coarse aggregate, examination of specific gravity and absorption of fine aggregate and coarse aggregate, examination of aggregate content weight, and compressive strength testing on concrete samples and checking linear regression formulations.

## 4. TEST RESULT AND DISCUSSION

Sieve analysis is a grouping of large items of coarse aggregate analysis and fine aggregate into a composite composition that is reviewed based on the filter.

The goal of sieve analysis are :

- To obtain concrete that easy to be worked and has a high level of workability.
- To obtain economical price of concrete and high durability.
- To obtain a solid concrete.
- To obtain a gradation limit from aggregate
- To obtain a mix composition of coarse and fine aggregate analysis in the ideal form.

The mixed aggregate is a comparison between fine aggregate and coarse aggregate in the manufacture of concrete in both light and structural concrete. The purpose of adding the aggregate of this mixture is to compare the theoretical results of the

planned concrete mixture using a linear regression formulation to obtain fine modulus. Fine modulus is a value that is used to show the smoothness and roughness of the aggregate items that are left / held above the sieve set. The greater the value of fine modulus, the greater the aggregate items. The following are the results of the STT PLN laboratory test :

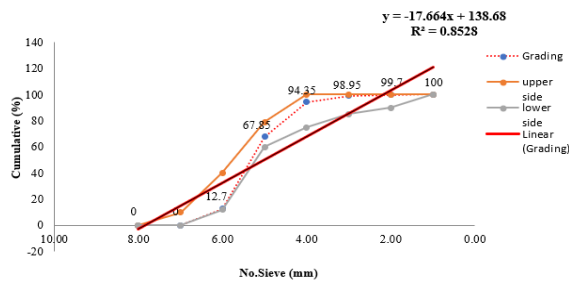


Fig. 3 Analysis of Linear Regression

Table 1 Fine Aggregate Data with Bangka Sand

Table 2 Percentage Cummulative

Particle size (mm)	Percentage Cummulative (%)						Specifications of Mixed Aggregate Gradation Maximum Grain Size 40 mm		
	Coarse Aggregates (K)	Fine Aggregates (P)	1,5 x K	1 x P	d + e	f/(P+K)			
a	b	c	d	e	f	g	Curve 1	Curve 2	Curve 3
38	100	100	150	100	250	100	100	100	100
19	53.14	100	79.71	100	179.71	72	74	86	93
9.6	2.64	100	3.96	100	103.96	42	47	70	82
4.8	1.38	99	2.07	99	101.07	40	28	52	70
2.4	0	96.4	0	96.4	96.4	39	18	40	57
1.2	0	83	0	83	83	33	10	31	46
0.6	0	40.6	0	40.6	40.6	16	6	21	32
0.3	0	11.2	0	11.2	11.2	4	4	11	19
0.15	0	1	0	1	1	0	0	1	4

Calculations are carried out statistically to obtain the amount or  $\sum$  of each calculation. The amount of each calculation data above will be used in the calculation of fine modulus on sand and gravel, the results of the fine modulus obtained must be in accordance with SNI standards. Where SNI requirements for fine modulus of sand are 1.5 - 3.8 and fine aggregate modulus is 6.5 - 7.5. From Fig. 4 above obtained in the calculation in accordance with the standard. So the fine modulus of the mixture and the results of the ratio of the percentage of fine

Sieve	Upper Side	Lower Side	Result
9.6	100	100	100
4.8	90	100	99.7
2.4	85	100	98.95
1.2	75	100	94.35
0.6	60	79	67.85
0.3	12	40	12.7
0.15	0	10	0
pan	0	0	0

The strength of the relationship between variables x and y is measured by the correlation coefficient. Correlation coefficient values are in the range -1 until 1 ( $-1 \leq r \leq 1$ ). When the coefficient is -1 or 1, then the data is said that the relationship between variables is perfect where events in variable y can be explained or predicted by variable x without errors.

aggregate: coarse aggregate = 60%: 40%. The specification data is based on SNI provisions so that data for curve 1, curve 2 and curve 3 are obtained.

From Fig.4 shows that the aggregate gradation combined for the maximum grain of data obtained is the amount of fine aggregate (sand) and coarse aggregate of 40mm, so that the curve obtained has met the standard. From the calculation of the data using a linear regression formula, which is through the set collected data which is illustrated through the scatterplot [5] to get results that are more accurate and

in accordance with the results, namely  $R^2 = 0.9775$ .

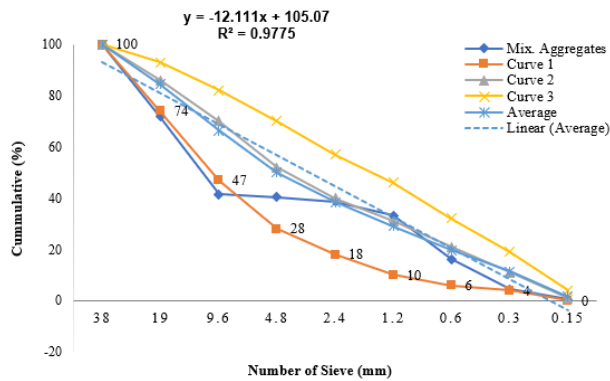


Fig. 4 Mixed Aggregate Gradation

Table 3 . Compressive Strength Test Results

Test Object (code)	Age (Days)	Cross-Sectional Area (mm)	Load (kN)	Compressive Strength (Mpa)
RH 1	3	17622.5	150	8.512
RH 2		17622.5	130	7.377
RH 3		17622.5	140	7.944
RH 1	7	17622.5	170	9.647
RH 2		17622.5	175	9.930
RH 3		17622.5	160	9.079
RH 1	14	17622.5	200	11.349
RH 2		17622.5	210	11.917
RH 3		17622.5	220	12.484
RH 1	21	17622.5	230	13.051
RH 2		17622.5	240	13.619
RH 3		17622.5	250	14.186
RH 1	28	17622.5	260	14.754
RH 2		17622.5	270	15.321
RH 3		17622.5	280	15.889

The magnitude of the correlation coefficient can be determined based on the distribution of the coordinates of the x and y variables. If the distribution of points is in a perfectly straight line, it can be said that the correlation value is 1 or -1 (positive and negative values depend on the direction of the distribution of points). Through correlation analysis, it can be informed that X and Y are closely related

## 5. ANALYSIS

### 5.1 Gradation Analysis of Fine Aggregate

The fine aggregate (sand) used in this study is bangka sand, in general the quality of bangka sand has fulfilled the requirements to be used as building material. However, the testing phase needs to be

carried out before it is used for concrete mixture. The following is the result of a sand inspection carried out in a concrete technology laboratory.



Fig. 5 Result of Sand Gradation (mm)

In fine aggregate grading testing using a set of sieves from sieves with particle size 9.6 mm in diameter, 4.8 mm, 2.4 mm, 1.2 mm, 0.6 mm, 0.3 mm, 0.15 mm. The sieve with the largest diameter particle size is placed at the top then the smallest diameter sieve is placed at the bottom. After that, the sand is sieve using a sieve shaker and the sieve is weighed.

Fig. 6 Fine Aggregate Gradation Analysis

$$\text{Modulus of Sand Fineness} = \frac{\text{Total \% Cumulative Left Weight}}{100\%}$$

Based on the results of testing that Bangka sand is

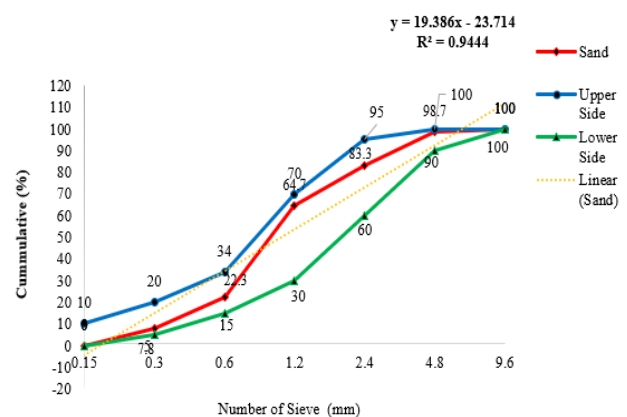


Fig. 6 Fine Aggregate Gradation Analysis

included in the fine sand category (Zone I) with a modulus of sand fineness obtained at 3.232 This fineness modulus fulfills the requirements specified in SNI 03-6820-2002, namely with the modulus of



smoothness of sand 2 - 3 and Bangka sand can be used as the main material of concrete mixture.

To find out the zone and category of sand types, it can be seen in the table below :

Table 4 Limits and Results of Test Sand Gradations[5]

Number of Sieve (mm)	% fine aggregate through a sieve				% Cumulative Fine Aggregate (Bangka Sand)
	Coarse (Zone I)	Rather Coarse (Zone II)	Rather Fine (Zone III)	Fine (Zone IV)	
9.6	100	100	100	100	100
4.8	90 - 100	90 - 100	90 - 100	95 - 100	100
2.4	60 - 95	75 - 100	85 - 100	95 - 100	99
1.2	30 - 70	55 - 90	75 - 100	90 - 100	96.4
0.6	15 - 34	35 - 59	60 - 79	80 - 100	83
0.3	5 - 20	8 - 30	12 - 40	15 - 50	40.6
0.15	0 - 10	0 - 10	0 - 10	0 - 15	11.2

## 5.2 Gradation Analysis of Coarse Aggregate



Fig. 7 Coarse Aggregate Gradation Results

Coarse aggregate in the form of gravel as shown in Fig. 7 is an aggregate that all the grains are left above the 4.8mm sieve. From the results of the coarse aggregate lab test calculations, the graph calculations are as follows :

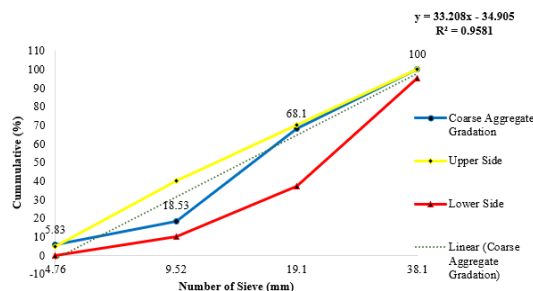


Fig. 8 Coarse Aggregate Gradation Analysis

Characterization of quality of materials is

important to ensure good use of resources from environmental and economic perspectives. Particle size distribution of materials is one of the widely used tests in geotechnical engineering to evaluate quality of materials. Sieve analysis test has been used as the main method to determine particle size distribution of granular materials including coarse materials for many decades[6]. Based on the results (Fig.8) of the gravel gradation analysis test shows that it has varying size shapes with 38.10 mm filter size. The result for fineness modulus obtained is 7.62 where the value of the modulus of fineness meets the requirements according to SNI 03-6820-2002[7] is the value of the modulus of fineness is not more than 8% with size around 5-8 mm and this coarse aggregate can be used as the main material for concrete mixture.

## 5.3 Concrete Compressive Strength Analysis

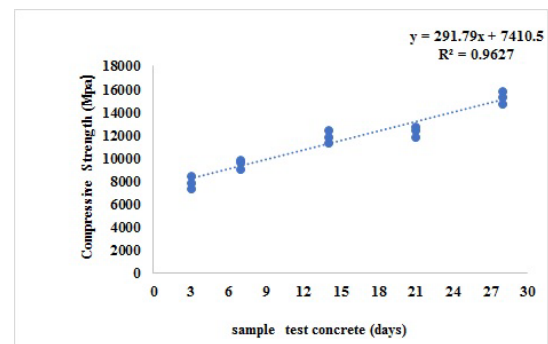


Fig. 9 Compressive Strength

Simple linear regression is a linear relationship between one independent variable (X) with a

dependent variable (Y). These analyzes are used to determine the direction of the relationship between the independent variable and dependent whether positive or negative and to predict the value of the dependent variable if the value of the independent variable increases or decreases in value[8][9]. Data used is usually interval scale. Regression analysis aims to explain or model the relationships between variables.

Table 5. The value of the Linear Regression correlation coefficient according to Gulford [10]

No.	Correlation Coefficient Values	Notes
1	0 - < 0.2	Very small correlation can be considered no correlation
2	$\geq 0.2$ - < 0.4	Small relationship / not close
3	$\geq 0.4$ - < 0.7	Moderate / Medium relationship
4	$\geq 0.7$ - < 0.9	Close relationship
5	$\geq 0.9$ - < 1	Very close relationship

Correlation analysis aims to determine whether there is a relationship between variables and the closeness of the relationship. Correlation is a number that shows the direction and strength of the relationship between the variables studied. The direction of the relationship between variables can be positive and negative and 0 (zero) if there is no relationship at all. The strength of the relationship between variables can be expressed by the magnitude of the correlation coefficient value on the linear function. From Fig. 3 Fig.4, Fig.6, Fig.8 (regression results) can be concluded that the two X variables and Y variable can be said to have a positive relationship if the increase in X variable is followed by an increase in Y variable, while the X variable and Y variable can be said to have a negative relationship if for every increase in X variable followed by a decrease in Y variable.

The Pearson values correlation (r) can describe the extent to which the data cluster around a straight line. Therefore from Figure 9 scatterplot correlation follows the line with a positive slope, it can be said that there is a high positive correlation between the two variables X and Y

## 6. CONCLUSION

From the results of data processing for laboratory testing results is aggregate gradation affects the nature of concrete produced by mixing coarse aggregates and fine aggregates should take into account their gradations. Therefore:

1. By using mixed aggregate comparisons, the quality of concrete is guaranteed

2. Fine modulus of the grains obtained is in accordance with SNI, the result is fine aggregate modulus is 3.232 and coarse aggregate modulus is 7.62
3. From calculations for the results of Linear Regression  $R^2$  for fine aggregate = 0.9444, for coarse aggregate = 0.9581 and for compressive strength = 0.9627 it means that it has a strong relationship for each variable and can be accounted for the implementation of concrete for good quality.

## 7. RECOMMENDATION

It is better to do with a sample with more variation so that it ensures whether the application of linear regression can be applied.

## 8. ACKNOWLEDGMENTS

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