



CORRELATION BETWEEN DCP AND CBR ON SUBBASE WITH GGBFS AS REPLACEMENT FOR FINE AGGREGATE

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INTRODUCTION

Subbase is a layer of construction that continues the load from the base to the sub grade in the form of compacted grained material. The government's new roads needs of a large amount of natural aggregate to fulfill the target. The use of natural aggregate for construction which is done massively and continuously will make it scarce. The replacement of fine aggregate with waste material such as ground granulated blast furnace slag (GGBFS) will prevent the environmental imbalance. When replacement is conducted, the strength of the new subbase need to test using California bearing ratio (CBR). Civil engineering always encounter difficulties in obtaining representative CBR values for pavement layers because the CBR test is time consuming and it cannot be easily determined in the field. While using DCP test just takes a very short time for analysis and interpretation. In this study, the correlation between DCP and CBR values of will be conducted to evaluate the relationship between them are strong or weak due to alternative test of subbase strength.

A study from Neeraja (2018), about the utilization of ground granulated blast furnace slag (GGBFS) and fly ash in granular subbase layer. The study evaluated the compaction and California Bearing Ratio (CBR) tests of conventional material for strength parameters, and a comparative study is made to know the variation of strength by replacing a known percentage of conventional material with granulated blast furnace slag and fly ash under different proportions. Based on Sahoo et al. (2009), there is strong correlation between CBR and DCP value. The strength between two variables are provided from the R-square results. According to Farshad (2003), Ferede (2010), and Ehsan (2011) mentioned that most of the relationships developed between DCP and CBR are based on the best fit log-log equation having the form:

$$\log (CBR) = A + B \log (DCP)$$

Where,

CBR = California Bearing Ratio (%)

DCP = penetration value (mm/blow)

A and B are regression constants for the relationships.

LIMITATION

Before starting the research, limitation should be made in order to accomplish the main objectives. These are the limitation for this research:

1. The soil that will be used is obtained from Berbah, Yogyakarta.
2. The coarse aggregate used is obtained from Clereng.
3. The natural fine aggregate used is obtained from Merapi.
4. The ground granulated blast furnace slag is obtained from PT. Krakatau Semen.
5. The base mixture of 10 : 50 : 40 (Soil : Coarse aggregate : Fine aggregate) will be used.
6. The variation of fine aggregate substitution with ground granulated blast furnace slag will be 0%, 15%, 30%, and 45%.
7. The correlation test between CBR and DCP value on subbase course is only carried out on unsoaked condition.

Methodology

1. Test Sample

This samples will be formed in cylinder with 15.2 cm diameter and 12.7 cm height. Based on previous study done by Cassiopheia (2014), the subbase mixture will use the ratio of 10 : 50 : 40 for soil : coarse aggregate : fine aggregate. Then, the variation of ground granulated blast furnace slag as fine aggregate replacement will be tested.

2. Soil

In this study, the soil that used is taken from Berbah, Yogyakarta. Further tests are going to be done on the soil to seek out its gradation and index properties, so the soil will be classified.

3. Ground Granulated Blast Furnace Slag

The natural fine aggregate will be replaced partially by the ground granulated blast furnace slag (GGBFS) on different mixes to evaluate the effect on the CBR value on unsoaked condition. In this study, the GGBFS is obtained from PT. Krakatau Semen.

4. Natural Coarse Aggregate

The natural coarse aggregate in this experiment is coming from Clereng. The coarse aggregate comes from a big stone that got crushed in stone crusher. The Los Angeles Abrasion test was used in this study to fulfill the requirement of LAA value. This test is needed to measure coarse aggregate resistance from crushing, degradation and disintegration.

5. Natural Fine Aggregate

In this study, the natural fine aggregate is mined from Kali Progo. This material was bought from a building material shop in Babarsari, Yogyakarta.

The mixtures of the subbase variation was described in table 1 below.

Table 1. Subbase Mixture Variation with Fine Aggregate Replacement

Composition (Soil : Natural Coarse Agg. : GBFS : Fine Agg.)	Aggregate Replacement	Total Sample
10 : 50 : 0 : 40	0%	3
10 : 50 : 6 : 34	15%	3
10 : 50 : 12 : 28	30%	3
10 : 50 : 18 : 22	45%	3

To investigate the correlation between DCP and CBR value, several laboratory test such us California bearing ratio (CBR) and dynamic cone penetrometer (DCP) test were conducted. The mold is arranged vertically to get enough depth for the DCP test. To get the valid data, every DCP test was done twice in the subbase mixtures samples.

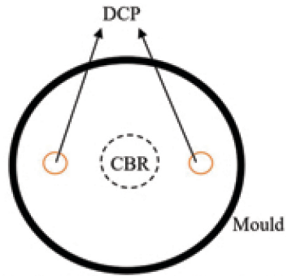


Fig. 1. Sketch of DCP Test in Subbase Mixture Samples (Top View)

Testing equipment that will be used is Dynamic Cone Penetrometer (DCP). This equipment consist of a 16 mm diameter steel rod and a 30 degrees cone angle is attached. The DCP is driven into soil by an 8 kg drop hammer with fall height of 575 mm. The explanation of the DCP testing equipment can be seen in the sketch below.

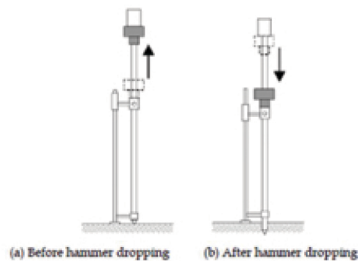


Fig. 2. DCP Testing Tools

The CBR and DCP test were carried out 3 samples from each variant; 0%, 15%, 30%, and 45%. The summary of the CBR and DCP value can be seen on the table 2 below.

Table 2. Summary of CBR and DCP Value

Aggregate Replacement	CBR 0.2"	DCP
0%	70.79	8.78
	70.79	8.75
	80.66	8.27
	80.66	8.33
	74.3	8.65
15%	74.3	8.35
	78.9	7.27
	78.9	7.40
	76.12	7.97
	76.12	7.56
30%	79.62	7.27
	79.62	7.18
	93.91	5.64
	93.91	6.17
	97.94	5.28
	97.94	5.40
	99.76	5.14
45%	99.76	5.24
	87.03	6.75
	87.03	7.09
	85.6	6.93
	85.6	7.17
	93.91	6.58
93.91	6.29	

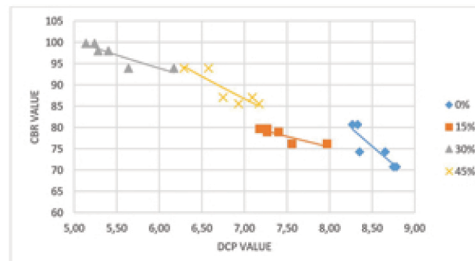


Fig 3. DCP - CBR Value Relationship of Fine Aggregate Replacement with GGBFS

Table 3. Excel Results Analysis with Fine Aggregate Replacement

Variant	Equation	R	R ²	Standard Error	t - test	P - value	F
0%	Ln CBR = 387.55 - 145.8Ln DCP	0.8792	0.7730	0.0123	3.6907	0.0210	13.6212
15%	Ln CBR = 154.53 - 38.03Ln DCP	0.8783	0.7714	0.0420	3.6735	0.0213	13.4947
30%	Ln CBR = 157.56 - 35.53Ln DCP	0.8827	0.7791	0.0333	3.7561	0.0198	14.1079
45%	Ln CBR = 224.37 - 70.73Ln DCP	0.8743	0.7644	0.0202	3.6022	0.0227	12.9760

DISCUSSION

In this research, it can be seen that there is a strong relationship between CBR and DCP value for each fine aggregate replacement with GGBFS. From the table 3, from the four variants above, it can be known that the best results are from the 30% aggregate replacement variant. From the five tests performed on each variant, at 30% aggregate replacement, four tests got the best results.

Where the results include R², F-test, t-test, and P-value. From the R² on 30% aggregate replacement got the greater value on 0.7791, F value is the greater that is 14.1079, the greater t - test value on 3.7561, and also the smaller P - value is 0.0198. The best standard deviation results value has on 0% aggregate replacement. From the figure 3, can be known that the best results are from the 30% aggregate replacement, the higher one.

CONCLUSION

Based on the research, it can be concluded that there is a strong relationship between CBR and DCP value for each fine aggregate replacement with GGBFS. From the four variants, it can be known that the best results are from the 30% aggregate replacement variant. From the five tests performed on each variant, at 30% aggregate replacement, four tests got the best results.

In this study, this approach is reliable for application in subbase evaluation and could enhance the credibility of the DCP as an accurate, portable, and yet inexpensive method of testing. As the determination of CBR by this method is time consuming and requires the use of costly equipment, another but the most accurate and indirect method is by using a dynamic cone penetrometer.

References:

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