TECHNIUM

Technium Vol. 25, pp.53-59 (2024)
ISSN: 2668-778X
www.techniumscience.com

BEHAVIOR OF CBR VALUE OF LATERITE SOIL MIXED WITH METAKAOLIN

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ABSTRACT

Laterite soil is a material widely used for civil engineering purposes in South Kalimantan. Most laterite soil has low bearing capacity due to high clay and plastic content, causing cracks and damage, especially when mixed with a fairly high volume of water. Therefore, this study aimed to improve the soil through stabilization using metakaolin. An experimental study was conducted using laterite soil from Mount Kupang, Cempaka Village, Banjarbaru. This soil was mixed with metakaolin on various percentage variations of the mixture, namely 2%, 4%, 6%, 8%, and 10% of the weight. The incubation period of the sample commences from 3, 7, and 14 days. Some of the test conducted include soil consistency limits (Atterberg limit test), soaked laboratory, and unconfined compressive strength (UCT). The result showed an effect on the characteristics of laterite soil mixed with metakaolin. The Plasticity Index (PI) value of laterite soil experienced a constant decrease due to the influence of methakoline by 14.75%. The soaked CBR value increased in a mixture of 2 to 8% metakaolin, but there was a decrease in the case of 10% at a curing time of 3, 7, and 14 days. Furthermore, the maximum soaked CBR value in laterite soil samples was mixed with 10% metakaolin at a curing period of 14 days and experience a percentage increase of 43.47%. The maximum qu value also increased by 42.02% in a mixture of 8% metakaolin and decreased in a 10% metakaolin at a curing time of 14 days.
Keywords: laterite soil, metakaolin, incubation, soaked CBR

1. INTRODUCTION

Highlands and lowlands are the two main geographical features of South Kalimantan Province. The lowlands of this area include peatlands and swamps, which are soft soil conditions with relatively low bearing capacity values. This low soil-bearing capacity will cause structural failure in buildings, roads, bridges, and sheet pile foundations. The California Bearing Ratio (CBR) is a strength test that is widely used in flexible pavement design throughout the world. The test shows essential soil characteristics, predicting the performance as a construction material (Imoh et al, 2019).

Laterite soil is commonly used in road construction, as a supporting layer that minimizes the effect of low subgrade on the pavement structure (sub-base and base course) (Pavement Design Manual, 2017). However, this soil has a low bearing capacity due to high clay and plastic content, causing cracks and damage, especially when mixed with a fairly high volume of water. To address this condition, improvement or stabilization is needed on laterite soil.

Metakaolin is an important material used as a supplementary cementitious material (SCM) in cement-based systems. This material is also used in the construction world and other studies for mixtures in concrete, in order to increase the compressive strength value. In Indonesia, studies on metakaolin are still rarely carried out for mixtures in soil as an alternative material for stability/improvement. Therefore, this study aimed to determine the behaviour of laterite soil when mixed with metakaolin against the soaked laboratory CBR value at various percentage variations of use and incubation time.

2. MATERIALS AND METHODS

Sampling of laterite soil was conducted by direct survey of the quarry to directly determine the original condition of the soil. Samples were taken to conduct physical-mechanical soil properties testing. The test object used was disturbed laterite soil originating from Mount Kupang Cempaka, Cempaka District, Banjarbaru City, South Kalimantan Province. Meanwhile, metakaolin was obtained from the seller distributor in the province.

Testing of physical and mechanical properties of laterite soil includes analysis of grain size distribution, compaction, Atterberg limit, immersion CBR, and unconfined compressive strength (UCT) test. In the immersion CBR and UCT test, the samples were cured for 0, 3, 7, and 14 days before testing with variations of metakaolin mixtures of 0%, 2%, 4%, 6%, 8%, and 10%.

3. RESULTS AND DISCUSSION

Physical Testing of Laterite Soil

Table. 1 Properties of Laterite Soil

Sample Number			Mount Kupang Laterite
Land Property	Specific Gravity (Gs)		2.670
Distribution of Granules	Gravel (> 2 mm)	%	3.42
	Coarse Sand (0.6-2.00 mm)	%	7.60
	Medium Sand (0.2 – 0.6 mm)	%	3.41
	Fine Sand (0.05-0.2 mm)	%	2.14
	Silt and Clay (0.002-0.05 mm)	%	1.64
	Clay (< 0.002 mm)		81.79
	No. 10 (2.00 mm)	%	96.58
	No. 40 (0.425 mm)	%	86.59
	No. 200 (0.0075 mm)	%	77.62
Atterberg Limits	Liquid Limit (LL)	%	61.19
	Plastic Limit (PL)	%	28.38
	Plastic Index (PI)	%	32.81
	Classification		CH
Compaction	Optimum Water Content	%	21.59
	Maximum Fill Weight (γd max)	kg/cm³	1.71

The test results showed the Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (IP) of 61.19%, 28.38%, and 32.81%, respectively. Based on this result, the laterite soil of Mount Kupang Banjarbaru was included in the Clay-High (CH) classification or inorganic clay with high plasticity (fat clay). The MDD value of laterite soil increased from 1.71 kg/cm^3 to 1.77 kg/cm^3 when mixed with 10% metakaolin. Meanwhile, OMC showed a constant decrease due to the loss of water by metakaolin for the pozzolan reaction with the silt and clay fractions in the soil.

Table. 2 MDD and OMC values of modified compaction test

Laterite Soil (%)	Metakaolin (%)	MDD (kg/cm^3)	OMC (%)
100	0	1.714	21.59
98	2	1.735	21.41
96	4	1.740	21.02
94	6	1.747	20.56
92	8	1,766	19.81
90	10	1,772	19.67

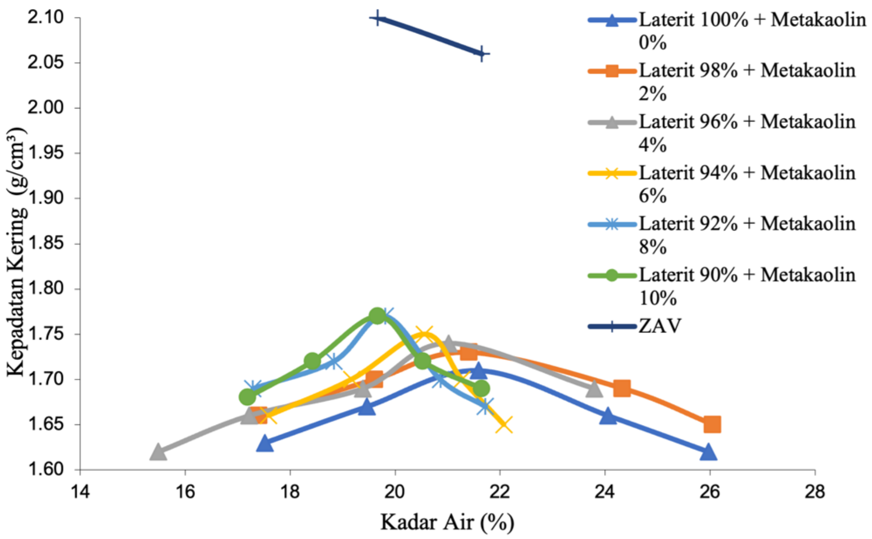

Figure. 1 OMC and MDD Value Graph

CBR *soaked* Laboratorium

Table. 3 CBR soaked test results

Mixed Percentage		CBR Value (%)			
Laterite Soil (%)	Metakaolin (%)	0 days	3 days	7 days	14 days
100	0	6.43	7.00	7.82	11.14
98	2	6.63	8.06	8.19	11.71
96	4	6.69	8.88	8.96	11.70
94	6	7.00	9.32	10.38	12.59
92	8	7.35	9.68	10.95	15.98
90	10	7.20	9.47	10.44	13.79

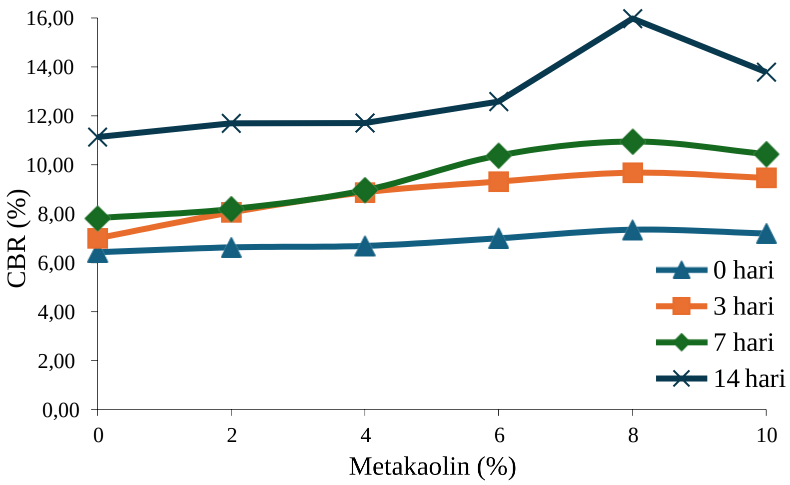

Figure 2. Graph of CBR Value of Immersion

The results in Table 3 and Figure 2 show that the addition of metakaolin to laterite soil can significantly increase the CBR immersion value at each percentage of the mixture and curing time. However, there was also a decrease in the CBR immersion value of laterite soil at curing times of 3, 7, and 14 days in a 10% metakaolin mixture. The highest CBR immersion value was found in a 10% metakaolin mixture with a curing time of 14 days which increased by 43.47%. The 14-day curing time also made Metakaolin react longer compared to 3 and 7. The optimal CBR immersion value of 15.98% also met the Binamarga specifications for selected embankments.

Unconfined Compressive Strength Test (UCT)

Table 4 UCT test results on compressive strength (qu) values

Mixed Percentage		qu value (kg/cm^2)			
Laterite Soil (%)	Metakaolin (%)	0 days	3 days	7 days	14 days
100	0	1.727	1.928	2.297	3.848
98	2	2.090	1.984	2.630	4.131
96	4	2.103	2.242	3.009	4.261
94	6	2.123	2.285	3.243	4.346
92	8	2.151	2.342	3.557	5.465
90	10	1.995	2.238	3.205	5.223

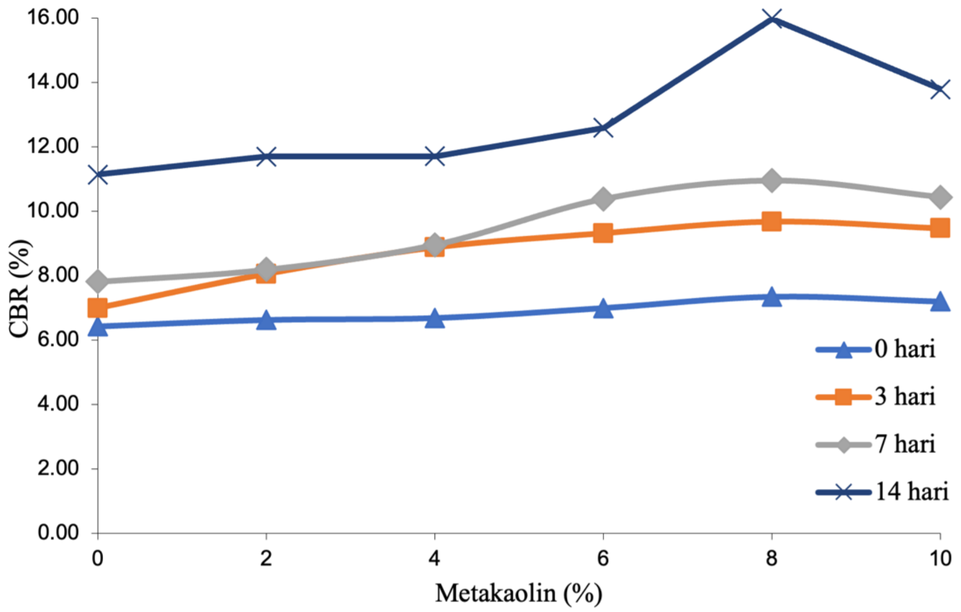

Figure 3. Graph of qu values

The data in Table 4 and Figure 3 show that the addition of metakaolin to laterite soil can increase the qu value at each percentage of the mixture and curing time. However, there was also a decrease in the qu value of laterite soil at curing times of 3, 7, and 14 days in a 10% metakaolin mixture. The largest qu value was found in a mixture of 8% metakaolin with a curing time of 14 days, a value of 5.465 kg/cm^2, a 42.02% percentage increase. There were similarities in the shape of the trend graph due to the correlation between the UCT value and the CBR value of immersion. In this case, increasing soil density will lead to a high UCT value.

4. CONCLUSION

In conclusion, the results of the laterite soil compaction test after being mixed with metakaolin showed an increase in the maximum dry weight value to 1.77 kg/cm^2 at an optimum water content of 19.67% with the addition of 10% metakaolin. The soaked CBR value added up to a mixture variation of 8% with a curing time of 3, 7, and 14 days experienced an increase but decreased at 10% metakaolin. Furthermore, the optimal soaked CBR value occurred when mixed with 8% metakaolin with a curing time of 14 days at 15.98%. This value met the Binamarga specifications for selected embankments. The maximum qu value in a mixture of 8% metakaolin with an incubation time of 14 days was 5.465 kg/cm2. Based on the qu value and consistency, the soil classification fell under hard clay and the optimal metakaolin additive percentage was recommended to be 8%.

5. REFERENCES

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