



Stabilization of Weak Lateritic Soil using Bitumen for Road Construction

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ABSTRACT

This paper titled stabilization of weak lateritic soil using bitumen for road construction was prepared with the aim of improving the weak or unsuitable construction materials (laterite) to enable its usage thereby reducing wastage and keeping the balance of borrow pit. The index properties of the soil were measured to identify the soil type and a varying percentage of bitumen 0, 6, 8, and 10% were stabilized with the soil. Compaction, California bearing ratio (CBR), and unconfined compressive strength (UCS) test were carried out and the results revealed that the CBR of the control was found to be 0.76%, and 0.92%, 0.2% and 0% for 6, 8, and 10% respectively. The maximum dry density (MDD) of the control was 1.761g/cm^3 at 16.88% optimum moisture content. At 6, 8 and 10% bitumen, the MDD were respectively 1.864g/cm^3 , 1.823g/cm^3 and 1.782g/cm^3 and their corresponding OMC were 14.78, 12.14 and 16.47% respectively. The UCS for the control was found to be 525 penetrations at 107.1kNm^{-2} . At 6, 8 and 10% the UCS were 60.69, 44.268 and 7.14kNm^{-2} at 325, 450 and 50mm penetration. The coefficient of permeability of the control was found to be $1.77 \times 10^{-5}\text{cms}^{-1}$. For the 6, 8 and 10% bitumen, the k values were respectively 7.49×10^{-6} , 2.68×10^{-5} and 1.2×10^{-5} .

Keywords: Bitumen, Compaction, Road, Stabilization, Strength, Soil

INTRODUCTION

Bitumen is the residual or by product obtained by fractional distillation of crude oil. It is the heaviest fraction and the one with highest boiling point. The use of bituminous materials such as cutback, bitumen, road tars and asphalted emulsion for soil stabilization has been found satisfactory for coarse grained or granular soil, which used in plastic soil, however may be difficult (Yoder, 1957).

Stabilization refers to those techniques that reduce hazards of a waste by converting the contaminants into their least soluble, mobile or toxic form. The physical nature and handling characteristics of waste are not necessarily changed by stabilization (Fleming, 2000). Stabilization of granular materials with low percentage of slow setting binders, such as slag lime for constructing new pavement and or rehabilitation of existing granular pavements has economic and environmental benefits.

Soil stabilization is the process of improving the physical and engineering properties of a soil to obtain some predetermined targets. This technique is done in order to render the material suitable and satisfactory for use as sub grade or sub base material for road construction. The chief aim of stabilizing a soil is to improve the soil strength, bearing capacity and durability under adverse stress conditions i.e.

stabilization is aimed at the enhancement of the engineering properties of deficient soils to enable them perform and sustain their intended engineering use (Osinubi, 2015)

(Kolo *et al.*, 2018) investigated the use of cold bitumen for stabilizing an A-6 lateritic soil with varying percentage replacement and found that the optimum bitumen content was at 6% replacement (3.5%). This research therefore is intended to check the effect of increasing the percentage replacement of the weak soil and also to measure its variations in permeability for use in road construction.

2 METHODOLOGY

2.1 Materials

The cold Bitumen was sourced from DALMAS Engineering Company Abuja. Portable water used was obtained from Civil Engineering laboratory while the soil was sourced within the campus of Federal University Technology, Minna.

2.2 Methods

By choosing to stabilize an existing sub-grade or sub base material, the costs associated with excavating the existing soil, removing it from the site, and replacing it with suitable materials are eliminated. This can result in substantial savings to the owner (Mukesh and Patel, 2012). To achieve the objectives



of the research, preliminary tests were run to classify the lateritic soil, these tests include; particle size distribution, Specific gravity, moisture contents and Atterbergs limit test. The samples were then mixed with the stabilizing agent to achieve the sample representation used for the research work.

Bearing Ratio (CBR) and Permeability were all conducted on the sample at 0, 6, 8, 10% percentage replacement all according to BS 1377 (1990) The results of compaction test (summary), CBR, UCS, permeability and other preliminary tests were all presented in the next section.

The Engineering properties such as compaction, unconfined compressive strength (UCS), California

3.0 RESULTS AND DISCUSSION

3.1 Atterberg Limit: The Atterberg limit test result revealed that the liquid limit value was 30.4 which yield a plasticity index of 6.2 as presented in Table 1.

Table 1: Atterberg limit

Liquid Limit Determination								
	LIQUID LIMIT					PLASTIC LIMIT		
Trial Number	1	2	3	4	5	1	2	
Penetration (mm)	4.20	9.60	12.00	17.00	22.00			
Wt. Of wet soil + Can	44.50	47.50	47.90	48.50	51.00	39.80	39.50	
Wt. Of dry soil + Can	43.40	45.80	45.80	46.00	48.10	39.50	39.20	
Wt. of Can	38.90	39.50	38.30	37.70	39.30	38.20	38.00	
Wt. Of dry soil	4.50	6.30	7.50	8.30	8.80	1.30	1.20	
Wt. of water	1.10	1.70	2.10	2.50	2.90	0.30	0.30	
Water content %	24.44	26.98	28.00	30.12	32.95	23.08	25.00	
Liquid limit %	30.40	Average Plastic Limit					24.20	

Liquid Limit (LL) = 30.40
 Plastic limit (PL) = 24.20
 Plasticity index (PI) = 6.20

3.2 Sieve Analysis: The particle size distributions result of the sample is presented in Figure 1. These parameters together with the obtained specific gravity value of 2.52 as illustrated in Table 2 were used to classify the soil as an A-7-5 using AASHTO Classification.

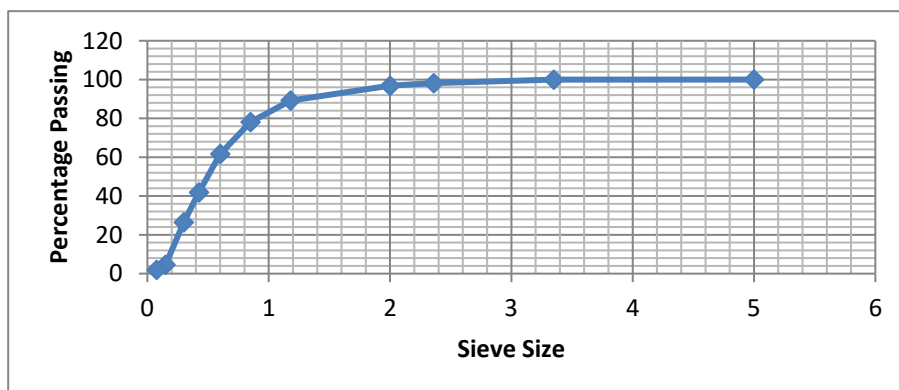


Figure 1: Particle size distribution for the lateritic soil



3.3 Specific Gravity

Table 2: Specific Gravity Result

	Laterite(A)	Laterite(B)
Mass of glass jar M_1 (g)	120.10	116.60
Mass of glass jar + soil sample M_2	141.40	139.60
Mass of glass jar + soil sample + water M_3 (g)	458.20	448.10
Mass of glass jar + water M_4 (g)	445.30	434.30
$M_2 - M_1$ (g)	21.30	23.00
$M_4 - M_1$ (g)	325.20	317.70
$M_3 - M_2$ (g)	316.80	308.50
$(M_4 - M_1) - (M_3 - M_2)$	8.40	9.20
$G_s = (M_2 - M_1) / (M_4 - M_1) - (M_3 - M_2)$	2.54	2.50
Average Specific Gravity	2.52	

3.4 Compaction:

The result also revealed that, 8% percentage replacement has a good correlation of compaction compare to 0,6, and 10% while the 6% has the highest MDD of 1.83 with a corresponding 14.26% OMC as illustrated in Figure 2

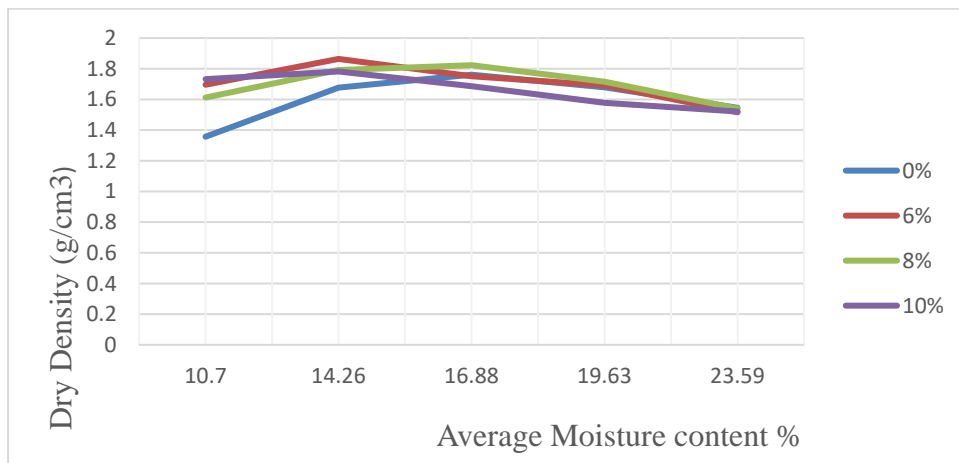


Figure 2: Compaction curves with varying Bitumen content

3.5 California Bearing Ratio (CBR): The CBR results shows that, the control value of the CBR is low and increases as the percentage of cold bitumen increases. Further increment in bitumen content resulted to a decrease in CBR value as presented in Figure 3. Therefore, the bitumen content must be carefully selected when used as a stabilizing agent.

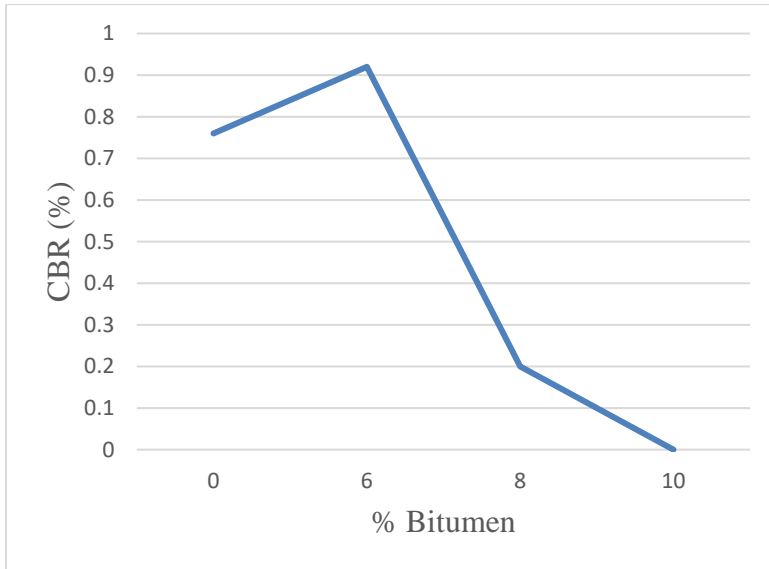


Figure 3: CBR for varying Bitumen Content

3.6 Unconfined Compressive Strength: The UCS of the bitumen stabilized laterite. The result of UCS was presented in figure 5. The result indicates that there is a sharp increase in UCS for bitumen between 0 to 6% which gently decreases between 6 to 10% of the bitumen content.

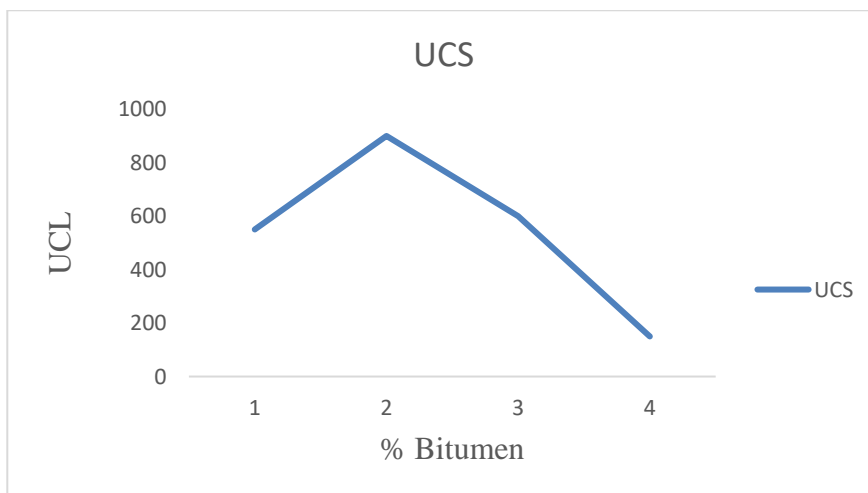


Figure 4: UCS with a varying Bitumen Content

3.7 Permeability: The permeability of the bitumen is important in evaluating suitability of bitumen as replacement in concrete design. It also assist in measuring the ease at which water can permeate from the road surface through the bitumen stabilized lateritic soil used for sub grade or sub base material. The coefficient of permeability increases consistently with increase in the bitumen content as shown Figure 5. This is similar to the findings of the Graves and Smith (2009).

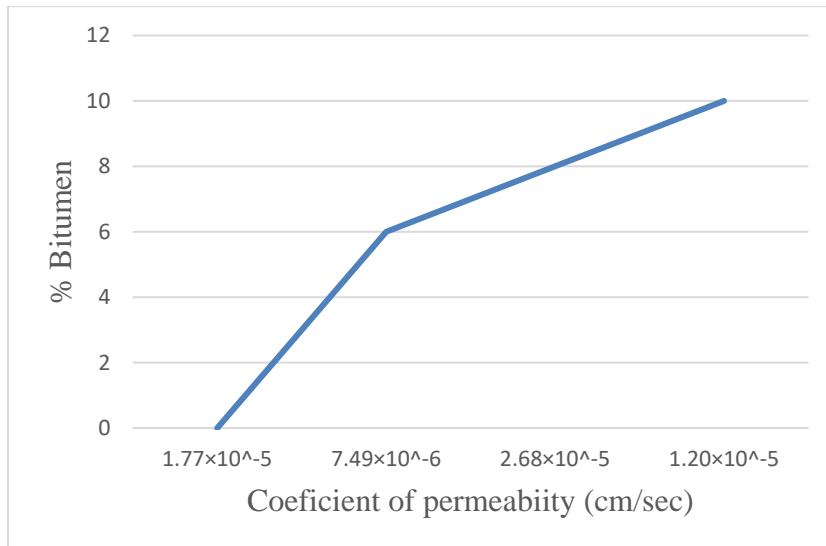


Figure 5: bitumen coefficient of permeability

4.0 CONCLUSION

1. The result revealed that 6% Bitumen content has the highest MDD of 1.83 with a corresponding 14.26% OMC and 10% Bitumen shows a clear disparity in the compaction curve.
2. The coefficient of permeability increases consistently with increase in the Bitumen content.
3. It can be deduced from the results that 6% bitumen content has better performance in terms of satisfying the test requirement for use in road construction.

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