ROAD STABILIZATION USING COLD BITUMEN FOR LOW TRAFFIC ROAD

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ABSTRACT

This research work is aimed at strengthening weak soil using cold bitumen for a low traffic road by stabilization method using varying percentages of cold bitumen (0%, 2%, 4% and 6%) to determine at which stabilization content is the soil strengthen for low traffic use. The lateritic soil used in this research work was collected at Kpakungu along Minna – Bida road and the cold bitumen was obtained in Minna. Standard laboratory tests were carried out on the lateritic soil. The tests carried out on the soil include particle size distribution determination, specific gravity test, Atterberg's limit test, compaction test and California bearing ratio test. The results obtained from the test showed that the optimum amount of cold bitumen in terms of effectiveness and economy was 3.5%.

Keywords: *bearing capacity, cold bitumen, stabilization, traffic and weak soil.*

1 INTRODUCTION

Bitumen can be defined as a mixture of organic liquid that are highly viscous, black, sticky, entirely soluble in carbon disulfide and composed primarily of highly condensed chemical compound or can be defined as an amorphous, black or dark colour (solid, semi-solid, or viscous) cementitious substance, composed principally of high molecular weight hydrocarbons, and soluble in carbon disulfide. 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. (Herbert, 2007).

Bitumen is an oil based substance. It is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. As such, it is correctly known as refined bitumen. In North America, bitumen is commonly known as "asphalt cement" or "asphalt". While elsewhere, "asphalt" is the term used for a mixture of small stones, sand, filler and bitumen, which is used as a road paving material. The asphalt mixture contains approximately 5% bitumen. At ambient temperature, bitumen is a stable, semi-solid substance.

Bitumen is any of various naturally occurring mixtures of hydrocarbons with their non metallic derivatives. Crude petroleum, asphalt and tar are bitumen which are characteristically dark brown or black and contain little Nitrogen, Oxygen, or Sulphur. Commercially, the term bitumen refers to hydrocarbon in a solid or semisolid state but in a wider sense, it refers to all natural hydrocarbons which may also occur in a liquid or gaseous state.

Bitumen is primarily used for paving roads and can also be used for stabilization where the soil is pulverized and mixed with bitumen to some percentage. In addition to this, bituminous materials and even high viscosity oil have been used for oiled earth road in which the road soil is simply sprayed on the prepared surface. Approximately, 85% of all the bitumen produced is used as a binder in asphalt for road construction. It is also used as a binder in asphalt for roads and for other paved areas such as airport, runways, car park and footways. A further 10% of global bitumen production is used in roofing applications where its water proofing qualities are in valuable. The remaining 5% of bitumen is used mainly for sealing and insulating purposes in a variety of building materials such as pipe coatings, carpet, tile backing and paints,

Also, 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 (Fleming, 2000).

2 MATERIALS AND METHOD

The preliminary test carried out on samples of lateritic soils collected include in-situ moisture content determination, sieve analysis, Atterberg's limit, compaction test and California bearing ratio test administering cold bitumen as a stabilizing agent compacted according to the procedure highlighted in BS I377 (1990).

The soil sample used for this study is a natural reddish-brown lateritic soil obtained at different locations along Minna – Bida road failed portions. Minna is located at latitude 6°30'N and 9°30'N. These samples were mixed together to obtained the sample representation which was then used to carry out this research work. The lateritic material was selected based on the fact that lateritic soil are the major road and rail construction materials of universal occurrence and acceptable, as such no construction work can be executed without the use of this material as described by Muazu (2008).

According to AASHTO soil classification system, the soil was classified through the following procedures (i) Determination of natural moisture content (ii) Determining the particle size distribution (iii) Atterberg limit determination (iv) Compaction test and (v) California bearing ratio tests.
The above tests were conducted on the soil sample while varying the quantity of the stabilizing agent. The main laboratory tests carried out includes Atterberg limit, compaction test and California bearing ratio test with cold bitumen as a stabilizing agent at 0%, 2%, 4% and 6% by weight of lateritic soil.

3 RESULTS AND DISCUSSION

3.1 Determination of Natural Moisture content

According to BS EN 1377:1 (1990) which states that more than 10% of natural moisture content is required for laboratory test. Result obtained from the experiment showed that the average moisture content in the lateritic soil in its state was 13.48%. Result is shown in Table 1.

Table 1: Determination of Natural Moisture Content

Can Number	A_8	Ab
Weight of Can (g)	25.60	25.62
Mass of Can +Wet soil, M_2(g)	61.72	72.68
Mass of Can +Dry soil, M_3 (g)	57.50	67.00
Mass of Dry soil, M_4(g)	31.88	41.40
Mass of Water, M_5 (g)	4.22	5.68
Moisture content, ω (%)	13.24	13.72
Average Moisture Content, ω (%)	13.48	

3.2 Particle Size Distribution

Results obtained from the particle size distribution of the soil give the distribution in percentages of the various sizes present in the soil sample down to fine sand. From the result obtained, the liquid limit is 35%, plasticity index is 23.59 and the group index is 8.25. Therefore, the soil can be classified using AASHTO method as A-6. The graph of the particle size distributions shows that the soil falls below the standard recommendation and require stabilization to improve its stability.

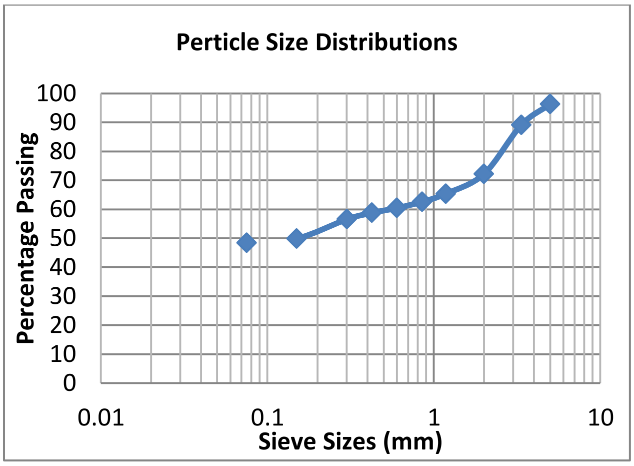

Figure 1: Particle Size Distributions

3.3 Compaction Test

Soil compaction test was carried out in order to determine the relationship between dry density and moisture content in the soil samples. The result of the compaction test carried out for the soil samples is shown in Table 2

From the graph plotted of the moisture dry density relations for the plain lateritic soil sample, it can be seen that as more water is added to the soil and then compacted, the dry density of the soil increases until it reaches maximum value, after which a further increase in the water content of the soil leads to a reduction in the dry density.

Table 2: Variation of Maximum density and Optimum Moisture Content with Cold Bitumen Content

Cold Bitumen Content	0%	2%	4%	6%
Moisture Content	9.2	10.12	11.65	13.42
MDD	1.75	1.81	1.81	1.73

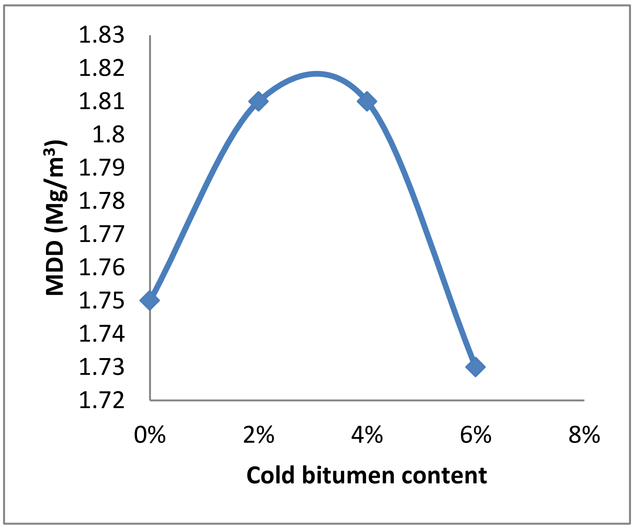

Figure 2: Variation of MDD with different cold bitumen content

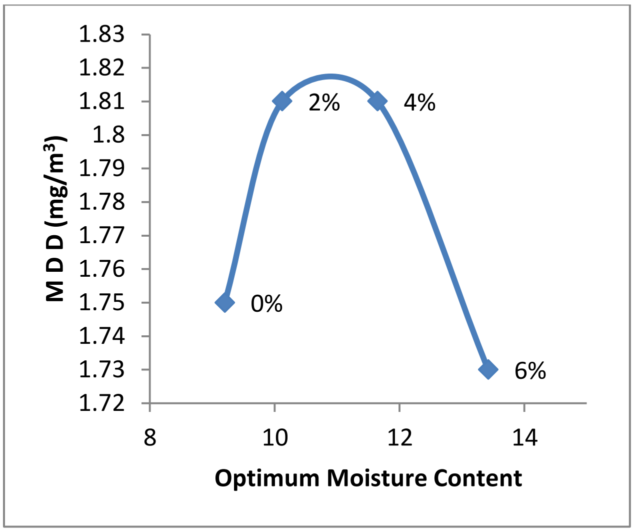

Figure 3: Variation of MDD with different Moisture content

3.4 Atterberg Limit Test

The Atterberg limit test was carried out to determine the liquid limit, plasticity index and also to determine the relationship between penetration and moisture content.

Table 3: Liquid limit test

0% Cold Bitumen		2% Cold Bitumen		4% Cold Bitumen		6% Cold Bitumen	
Moisture content	Pen	Moisture content	Pen	Moisture Content	Pen	Moisture Content	Pen
25.17	7	30.77	7.5	26.81	8.1	31.33	9.7
30.7	12	31.19	9.2	27.27	12.8	34.46	12.25
31.85	14.4	36.54	10.7	37.34	14.1	35.25	15.5
35.04	16.4	39.85	12.5	40.4	17.3	38.36	18.55
35.51	20.9	40.31	17.8	40.57	21	40.39	22.75

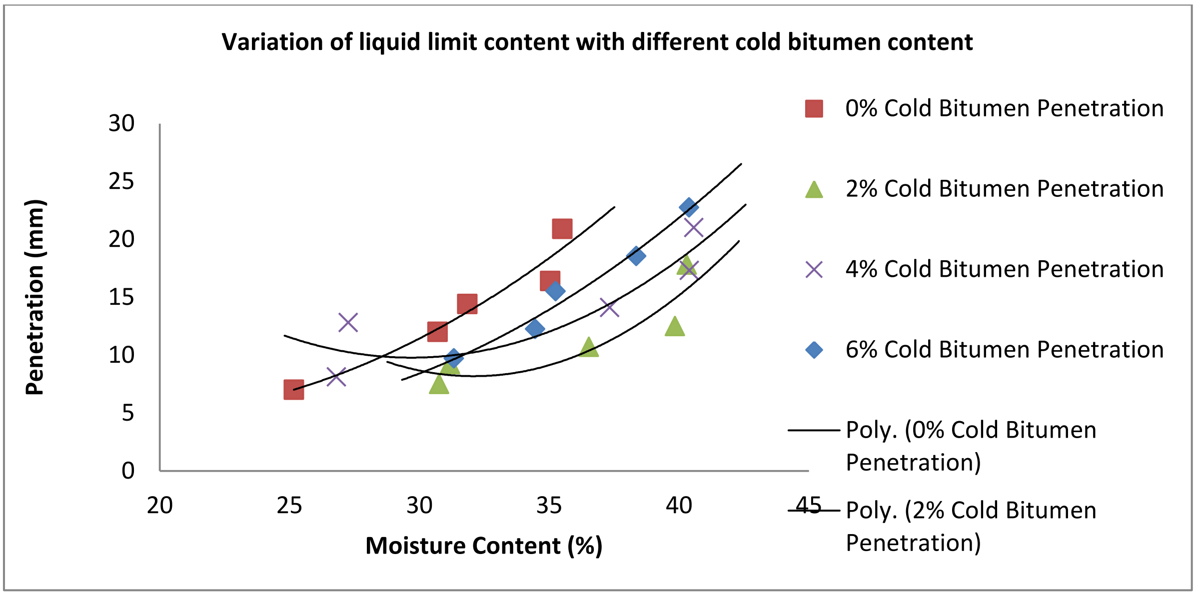

Figure 4: Variation of liquid limit content with different cold bitumen content

The trend shows that there is a corresponding decrease with increase of cold bitumen content in liquid limit, plasticity index. However, the reverse was the case for plastic limit. Liquid limit was obtained to be 42.0, 40.0, 39.0 at 2, 4, 6% respectively. While the corresponding plastic limit are 14.17, 15.04, and 15.41 for the same percentage of cold bitumen increment. The explanation consistent with complex behavior of liquid as a result of cold bitumen addition was due to decrease in void and aggregation of soil particles.

Table 4: Atterberg limit test

	0%	2%	4%	6%
Liquid Limit	35	42.5	40	39
Plastic Limit	23.59	28.33	24.96	23.59
Plasticity	11.41	14.17	15.04	15.41

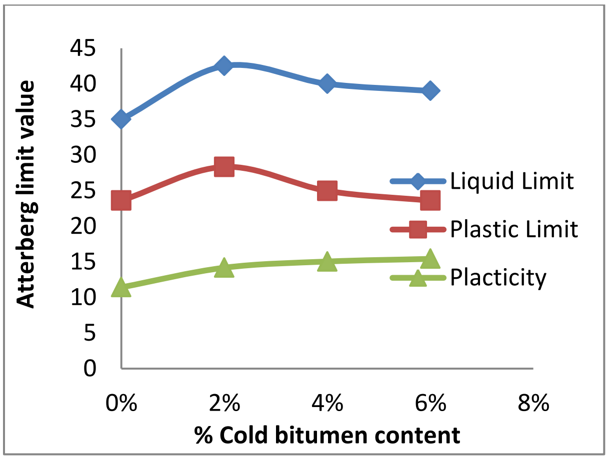

Figure 5: Variation of Atterberg limit with different cold bitumen

3.5 California Bearing Ratio

This method covers the laboratory determination of the California Bearing Ration (CBR) of a compacted or undisturbed sample of soil. The principle is to determine the relationship between force and penetration when a cylindrical plunger of a standard cross-sectional area is made to penetrate the soil at a given rate. At certain values of penetration, the ratio of the applied force to a standard force, expressed as a percentage, is defined as the California Bearing Ratio (CBR)

The penetration increases as the corresponding load also increases also the percentage of CBR at 5.00mm penetration is having higher value than that at 2.5mm which means it is suitable for base course.

Table 5: Obtained C.B.R Values

% Cold Bitumen content	Soak	unsoak
0%	37	40.5
2%	32.5	33.3
4%	33.6	34.5
6%	35.35	35.47

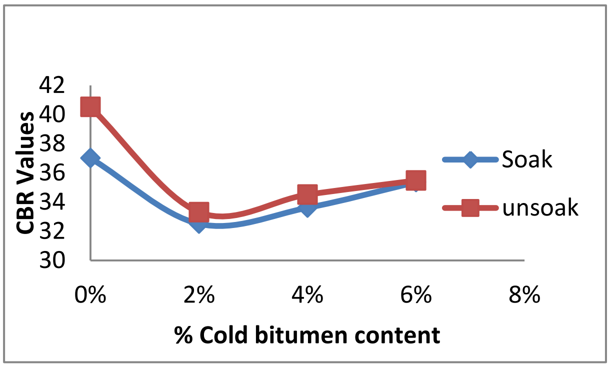

Figure 6: Comparison of CBR values of Soaked and unsoaked

4 CONCLUSION

The following conclusions were drawn from the result of the research carried out within the scope of the study.

1. The optimum effect of cold bitumen stabilization is achieved at six percent (6 %).

2. The laterite was identified to be an A-6 soil based on AASHTO (1986) classification system.

3. The maximum dry density and optimum moisture content varies with an increase in cold bitumen content.

4. The material has high liquid limit of 35% and plastic limit of 11.41%. It can conclude that it is non plastic.

RECOMMENDATIONS

1. It is recommended that cold bitumen should be widely accepted and encouraged in construction companies all over the world for better road construction.

2. Further research works should be carried out to determine the most effective and economic ratio for combined modification.

3. Index properties like liquid limit, plastic limit and plasticity index should be determined for all the admixture ratios studied to confirm the complete suitability of the mixture for engineering structures.

4. It could be recommended that the strength result obtained at optimum 3.5 % cold bitumen suggest that it is suitable as a sub-base material on road pavement.

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