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THE USE OF GUM ARABIC AS A LATERETIC SOIL STABILIZER

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ABSTRACT

This research work was conducted to ascertain the suitability of stabilizing lateritic soil with Gum Arabic and to determine the proper economic percentage which could improve the engineering properties of the soil. Sample of the lateritic soil was obtained and the Gum Arabic was purchased and prepared. The laboratory tests were carried out, according to the standards, using 0%, 2%, 4%, 6%, 8%, and 10% of the Gum Arabic by weight. From the result of Atterberg Limit test, 0% and 4% of Gum Arabic recorded the lowest and highest values of 15.93% and 26.25% of plastic limit respectively. The test also showed that the soil was in A-6 class of ASSHTO classification (clayed soils). While for shrinkage limit, 0% and 10% recorded the lowest and highest values of 10.00% and 12.14% respectively. In the compaction test, the MDD values decreased with an increase in the Gum Arabic in which 0% and 8% recorded the highest and lowest values of 1.88g/cm^3 and 1.64g/cm^3 respectively. For the compressive strength, 50% of the cubes tested, met the minimum strength requirement of 1.5N/mm^2 by the Civil Engineering Department of ABU Zaria, in collaboration with Nigeria Building and Road research institute for lateritic blocks. It is recommended, therefore, that the minimum of 2% of Gum Arabic be used to stabilize lateritic soil.

INTRODUCTION

Lateritic soils have been used successfully in various aspects of Civil Engineering constructions; as foundation materials, embankment in road constructions, dams and land reclamation. The needs for using locally available building and construction materials have been in the increase due to the high cost of conventional building materials.

Lateritic soils are the traditional materials for roads and airfields constructions in all the tropical and sub-tropical countries of the world. Usman (2004) said "In Nigeria, residential houses of most rural areas are built and are continuously being built with laterite". This laterite soil, in some cases, does not meet the requirement of its intended purpose. Thus, there is the need to embark upon researches into this material and to come up with a means of improving it qualities.

To enhance the usefulness of laterite, different types of modifiers have been used in different parts of the world. The most common ones are cement, lime, bitumen, rice husk ash and etc. The continuous increase in the cost of cement, lime and bitumen as modifiers or stabilizers is becoming uneconomical due to the global economic crisis.

There is therefore, the need to develop an alternative and more economical soil stabilization agent so as to achieve the same result as obtained with the other usual soil stabilizers.
In this research work, Gum Arabic will be considered as a lateritic soil stabilizer and see it effectiveness. According to Abdullahi (2004), GUM ARABIC is the dried exudates obtained from the stems or branches of Acacia Senegal or closely related species. It is a natural gum harvested from the exterior of Acacia trees in the form of dry, hard nodules up to 50mm in diameter and ranging from almost colorless to brown.

The plant tolerates water deficit and therefore able to endure conditions of prolonged drought associated with the arid region of Nigeria. The Gum Arabic growing states, in Nigeria, include Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara states. Globally, the majority of Gum Arabic found in International markets originates from the Gum belt of sub-Saharan African with Sudan accounting for about 80% of the world production and 60% of the market. Nigeria is the second largest after Sudan.
Gum Arabic plant serves as a fodder and for environmental protection including soil stabilization improvement, Abdullahi (2004).

Lateritic Soils are widely found in Nigeria as well as in other tropical and sub-tropical regions. These soils result from lateralization process. Lateritic soils do not contain only soil particles, but also decayed organic materials. In Nigeria lateritic soils are used as fills in most engineering construction works, such as road construction, embankment for road and dams, airport run ways etc. Although lateritic soil is found in abundance in most cases, it does not meet all the requirements for construction purposes.

Many studies have been carried out on different methods through which lateritic soil can be improved to meet the required constructional specifications. The possibility of using Gum Arabic as a modifier or stabilizer for lateritic soil and the suitable percentage or the quantity to be used has to be determined. Thus, if Gum Arabic can be used in small quantity as a lateritic soil stabilizer, it could be a good substitute to soil stabilization with cement and other agents.
The following properties were determined:
-The effect of Gum Arabic on the plasticity and optimum moisture content of laterite.
-The effect of various percentage addition of Gum Arabic on the compressive strength, Water absorption and dry shrinkage of laterite.
-The suitable percentage of Gum Arabic for lateritic soil
Stabilization and;
-The cost of laterite stabilization with Gum Arabic and that
of cement.

General Properties

Gum Arabic is unique among the natural hydrocolloids because of its extremely high solubility in water. Gum Arabic is insoluble in oil and in most organic solvents. It is soluble in aqueous

ethanol up to a limit of about 60% ethanol. Limited solubility can also be obtained with glycerol and ethylene glycol. Whereas most gums form highly viscous solutions at low concentrations of about 1-5%. High viscosities are not obtained with Gum Arabic until concentrations of about 40-50% are obtained. This ability to form highly concentrated solution is responsible for the excellent stabilizing and emulsifying properties of Gum Arabic when incorporated with large amounts of insoluble matters. The viscosity of Gum Arabic solutions will depend upon the type and variety of the Gum Arabic used. At concentration up to 40%, Gum Arabic solutions exhibit typical Newtonian behavior. Above 40%, solution takes up pseudoplatic characteristics as denoted by a decrease in viscosity with increasing shearing stress, Benecke, (2009).

In Nigeria, Gum Arabic is classified into 3 grades namely.

i. Acacia Senegal (grade 1)
ii. Acacia Seyel (grade 2)
iii. Combretum and other source, Abubakar (2004).

Gum Arabic is mainly produced from two Acacias that are found to a varying intensity in the belt of sub-Saharan Africa. The Acacias are; Acacia Senegal that produces hard gum and Acacia Seyel that produces friable gum, Macrac and Miller (2002).The Gum Arabic of commercial is water soluble exudates. The major source (95%) is Acacia Senegal while the remaining 5% is from Acacia Seyel, which are sold as an entirely separate product. Both trees species grow in various communities in the drier parts of Africa and Asia, Seifel (1969). Friable gum is considered to have a relatively low quality and may be used for a price advantage or when supplies of hard gum are low, Macrase and Miller (2002).

Gum Arabic is a complex, slightly acidic polysaccharide. The precise chemical and molecular structure differs according to the botanical origin of the gum. As a result, the functional properties and uses to which Gum Arabic can be put (and its commercial values) are very dependent on its origin.

Table 1.0 Average Composition of Acacia Gum
(Sugar Composition after hydrolysis)

Galactose	35-45%
Arabinose	25-45%
Rhamnose	4-13%
Glucuronic acids	6-15%
Molecular weight average	250,000
pH solution at 25%	4.4
Intrinsec Viscosity	12ml/g
Brookfield viscosity, solution at 25%, 60 rpm	70cp
Protein content	1-2%

Total ashes (Potassium, Calcium& sodium salts)	3-4%
Arabinogalactan (AG)	89-98%
Arabinogalactoprotien (AGP)	1-10%
Glyco proteins (GP)	Less than 1%

Grieve, (2009)

Table 2.0 Quality Standard for Gum Arabic

Minimum standards for good quality Gum Arabic have been defined in the United States Pharmacopeia USP 23 and by European Union specification E – 414 as shown in the table below;

Arsenic (as As) Ash (total) Ash (acid insoluble) Heavy metals (as Pb) Lead Insoluble matter Loss on drying	≤3ppm ≤4% ≤0.5% ≤40ppm ≤10ppm ≤1% ≤15%	Source Beneck, (2009)

No presence of starch, dextrin or tanni**ns by standard test.**

MATERIALS AND METHOD

Materials

The lateritic soil material (Sample) for this research work were obtained from Dikko Road Badiko, Kaduna, at a depth of 2.5m. The sample was completely air dried before the tests.
The Gum Arabic samples were purchased from old Panteka market. Due to the coarse nature of the Gum Arabic, the materials were grinded and sieved through sieve No 10 of BS sieves.

Method

The tests were conducted according to the normal standard for civil engineering soil investigation BS1377: 1990 and BS1924: 1990.
The percentages of the Gum Arabic mixed with the soil for this research work were 0%, 2%, 4%, 6%, 8%, and 10%.
For the compressive strength test, 10 number of cubes were cast per each percentage of the Gum Arabic, hence, 60 number of cubes were cast and crushed at 7, 14, 21, 28, & 56 days of curing (Air Dry curing).

The following laboratory tests were conducted:

1. natural moisture content (NMC)
2. Specific Gravity (G_S)

3. Atterbarg Limit Test
i. Liquid Limit (L.L)
ii. Plastic Limit (P. L)
iii. Plastic index (P. I)
iv. Linear shrinkage (L. S)
4. Particle size distribution (sieve Analysis)
5. Compaction
6. Compressive strength of lateritic cube.

RESULT PRESENTATION AND DISCUSSION

The results of the laboratory tests conducted are presented on the tables and figures in the appendix.

From the summary of result in table 4.0 and figures 4.1 and 4.2, in the appendix, generally, there was an increase in optimum moisture content (O.M.C) with addition of Gum Arabic. The addition also has significant effect on the maximum Dry Density (M.D.D) as there was a considerable decrease in the value of M.D.D.

Lateritic soils generally have some certain amount of water which makes the soils to attain their maximum Dry Density, any increase of water beyond this level makes the soil to experience decrease in density. As it has been observed, the percentage increase of Gum Arabic in the soil makes the soil mass to absorb more water which leads to a gradual increase in optimum moisture content and gradually decreasing the maximum Dry Density of the soil.

From table 5.0 and fig. 5.1 above, it was observed that the compressive strength of the cubes increased gradually with an increase in percentage of Gum Arabic as well as increase in curing age. However, highest compressive strength value of 3.33 N/mm^2 was recorded at 56 days of 10% addition of Gum Arabic. This gradual gain in strength could be due to long-term counting together of the soil particles at their points of interaction. This reaction, which is still not fully understood, possibly commences simultaneously with the flocculation process, and the possible cause of this reaction, which behaves similar to that of cement, could be as a result of the presence of calcium and magnesium in the Gum Arabic. "Thus, strength gain due to cementation is generally very much dependent on the amount and type of clay mineral present in the soil. The pozzolanic reaction between lime and the soil is considerably influenced by the amount and type of lime used" O Flaherty (1973).

CONCLUSION AND RECOMMENDATION

The choice of stabilizing additive largely depends on the availability, economy and the effectiveness of the additive as well as the type of soil involve.

CONCLUSION

1. The plasticity index of the soil samples decreased as 4% of Gum Arabic was added to the soil. With further increase of the Gum Arabic, the plasticity index slightly increases.
2. The optimum moisture content of the lateritic soil increased with addition of Gum Arabic, but the maximum Dry Density of the soil, slightly decreased.
3. The compressive strength of the lateritic cubes increase with an increase in the Gum Arabic with strength of 3.33 N/mm^2 at 56 days of 10% addition of Gum Arabic.
   With these highlighted properties, it could be concluded that Gum Arabic can be effectively used in stabilization of lateritic soil.

RECOMMENDATION

Based on the knowledge and experience acquired from this research work, the following recommendations are made:-

1. Minimum of 2% of Gum Arabic can be used for the stabilization of lateritic soil.
2. Further research using the same percentage as used in this research but should be in connection with other agents such as lime, cement etc.
3. Further research should be conducted on the effect of water on Gum Arabic Stabilized cubes.

Therefore, it has become necessary for the government and other non- governmental organizations to encourage the use of natural indigenous materials which are durable, cheaper and abundantly available.

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Table 3.0: Atterberg Limit test of the Lateritic Soil with Various Percentage addition of Gum Arabic

Gum Arabic (%)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Shrinkage Limit (%)
0	15.93	26.70	10.77	10.00
2	22.96	32.25	9.29	11.43
4	26.25	32.50	6.25	11.43
6	25.76	32.30	6.54	11.43
8	24.95	33.60	8.65	12.14
10	24.94	34.00	9.06	12.14

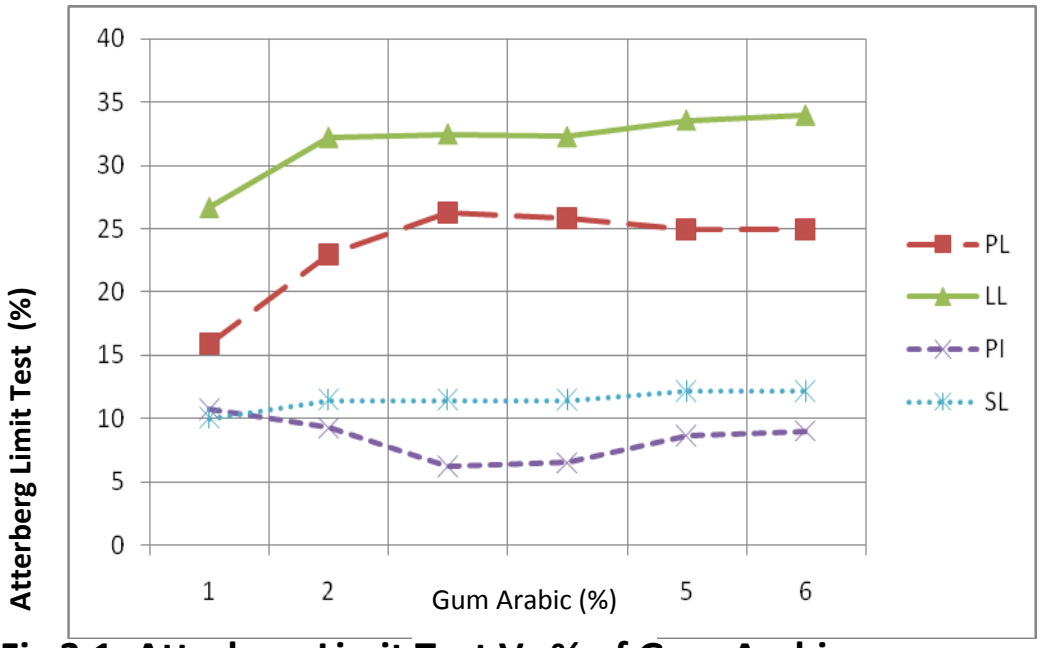

Fig 3.1: Atterberg Limit Test Vs % of Gum Arabic

Table 4.0: Optimum Moisture Content and maximum Dry Density for the lateritic soil at various percentages Addition of the Gum Arabic

Gum Arabic (%)	Optimum Moisture Content (%)	Maximum Dry Density (g/cm^3)
0	12.20	1.88
2	14.20	1.77
4	14.80	1.76
6	15.00	1.74
8	16.60	1.64
10	15.60	1.65

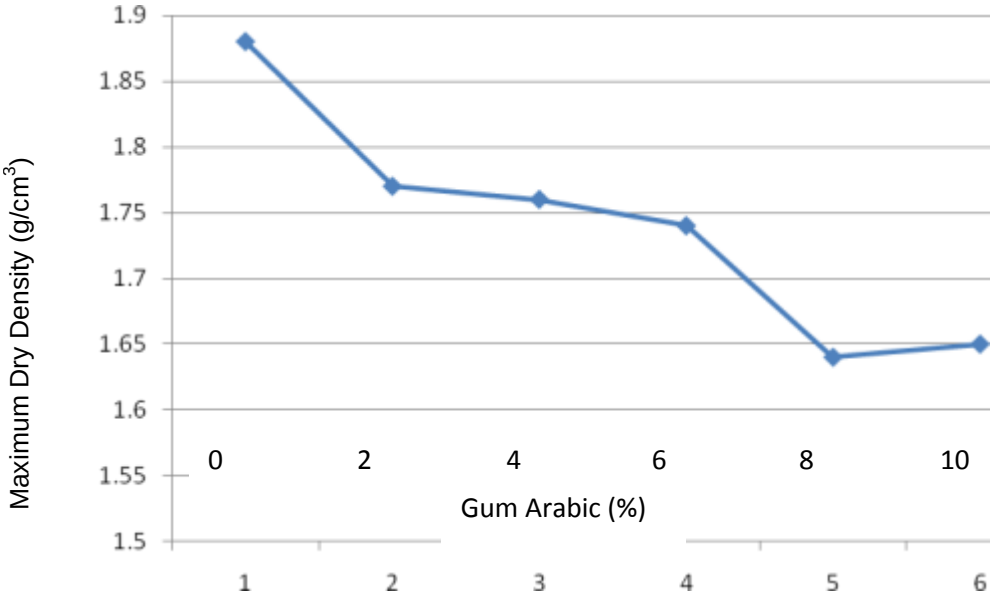

Fig 4.1 Maximum Dry Density Vs % of Gum Arabic

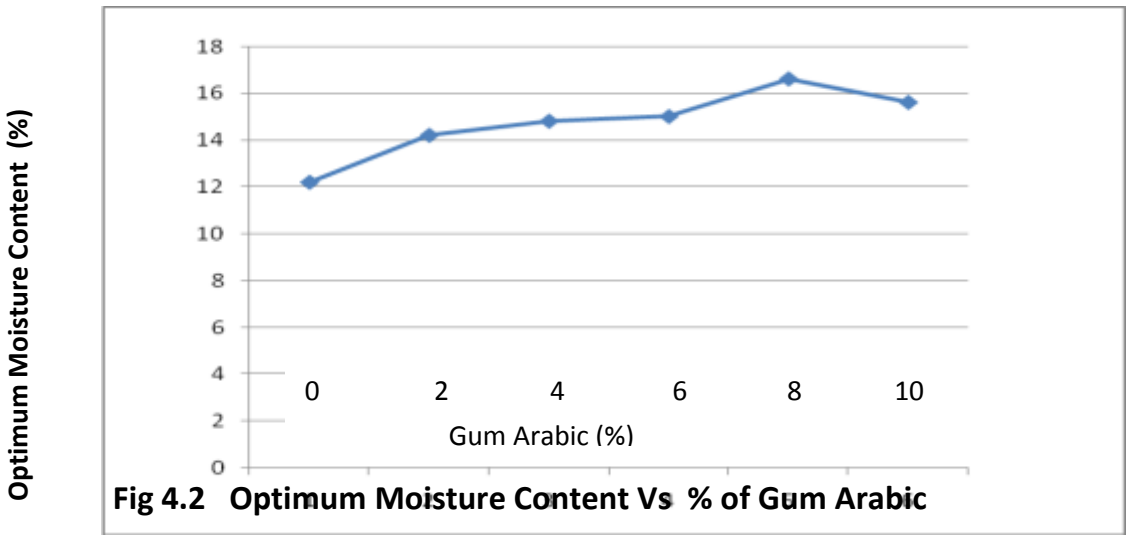

Fig 4.2 Optimum Moisture Content Vs % of Gum Arabic

Table 5.0: Compressive strength of Lateritic soil with various percentage addition of Gum Arabic

Curing Age	Gum Arabic (%)	Load at failure (KN)	Compressive Strength (N/mm^2)
7 days	0	15	0.67
" "	2	17	0.76
" "	4	18	0.80
" "	6	20	0.89
" "	8	22	0.98
" "	10	23	1.02
14 days	0	18	0.80
" "	2	20	0.89
" "	4	23	1.02
" "	6	26	1.16
" "	8	28	1.24
" "	10	30	1.33
21 days	0	29	1.29
" "	2	27	1.20
" "	4	33	1.47
" "	6	38	1.69
" "	8	46	2.04
" "	10	49	2.18
28 days	0	30	1.33
" "	2	35	1.56
" "	4	40	1.78
" "	6	44	1.96
" "	8	51	2.27
" "	10	54	2.40
56 days	0	33	1.47
" "	2	38	1.67
" "	4	44	1.96
" "	6	55	2.44
" "	8	63	2.80
" "	10	75	3.33

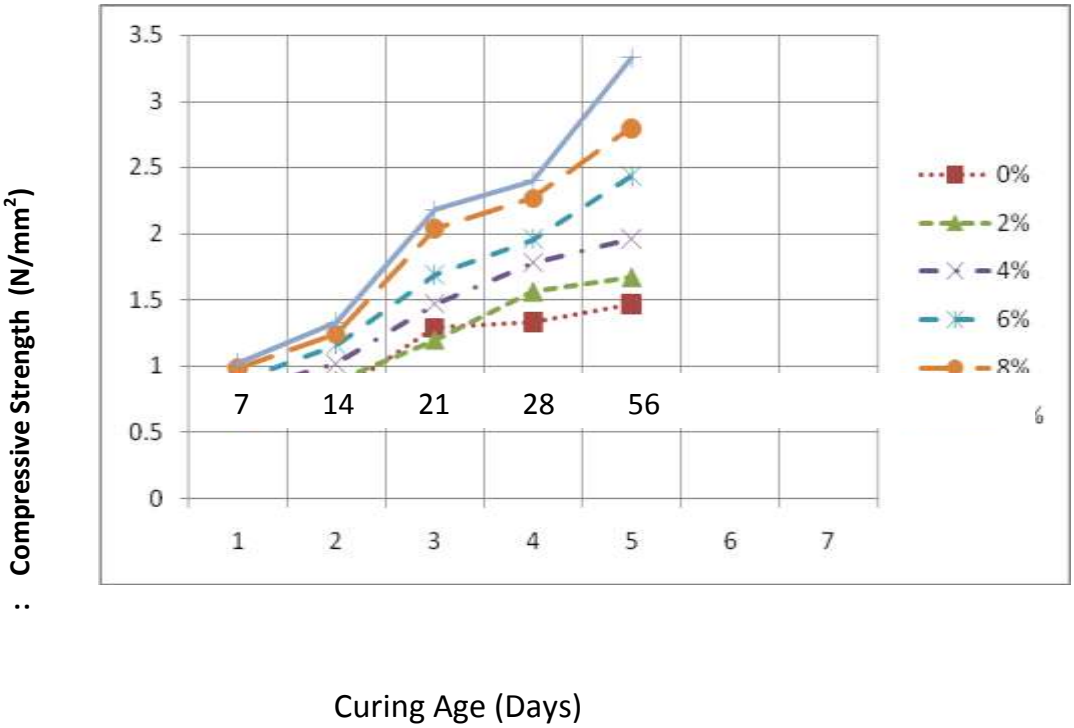

Fig 5.1: Compressive Strength Vs Curing Age 0f the cubes.