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Nylon Solution as Soil Stabilizer

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***Abstract*—**The research investigated the use of nylon solution to enhance the California bearing ratio (CBR) of soil. Used nylon sachet of potable water were dissolved in four separate solvents namely acetone, toluene, ethyl glycol and dual purpose kerosene (DPK). It was discovered that DPK has the highest nylon solubility of 29g/ml at 91^{o}C. The nylon solution was used to stabilize poorly graded sandy soil. The result showed that at less or equal to 4% stabilization, the CBR value decreased from 25.3% to 15.85% and later appreciated to 67.78% at 16% stabilization. The initial decrease in CBR value of soil sample observed was as a result of inadequate nylon solution to coat soil particles for proper bonding.

***Keywords*—**Nylon solution, Soil stabilization, Dual purpose kerosene, California bearing ratio.

I. General Background

ALMOST all foundations are cited on soils. The geotechnical engineers design structure foundations based on the prevailing soil properties after due and thorough site investigation. If soil just below the ground surface is sound enough, shallow foundation may suffice. However, if soil is not good, deep foundations may be adopted. Sometimes, the soil conditions are very poor and various remedial measures of improving soil properties are adopted. In case of road construction, the soil California bearing ratio influences the thickness of road elements needed to transmit axle loads safely to underlying soil. If the CBR of soil is very weak, measures are taken to improve it. The remedial measures are of two type namely mechanical and chemical stabilization.

The graduation of soil is very important property to keep in mind while working with soils. The soil may be well-graded which is desirable as it has less number of voids or uniform graded which though sounds stable has more voids. Thus it is better to mix together different soils to improve their strength. It is very expensive to replace inferior soil entirely and hence soil stabilization will yield better result [1]. Mechanical stabilization involves application of mechanical energy to moist soil to improve its strength and reduce ease of water percolation. Chemical stabilization entails addition of any of the following chemicals to improve or enhance soil properties such chemicals are calcium chloride, fly ash, quick lime, hydrated lime, Portland cement and bitumen.

The Mesopotamians and Romans separately improved the ability of pathways to carry traffic by mixing weak soils with limestone. Lime stabilization center on the fact that a pozzolanic reaction between silica or alumina in clay particles and calcium from lime can form cemented structure that increases strength of stabilized soil. Residual calcium must remain in the system to combine with available silica or alumina and to keep soil pH high enough to maintain the pozzolanic reaction [2]. Soils that should be considered for lime treatment include soils with plasticity index (PI) that exceeds 10 and have more than 25% passing through sieve no 200 [3]. Fly ash was successfully used to stabilize expansive soil [4]. Depending upon soil type, the effective fly ash content for improving engineering properties of soil varies from 15% to 30% [5] and [6]. Rice husk ash content of 12% and fly ash of 25% would increase unconfined compressive strength (UCS) and California bearing ratio (CBR) of expansive soil by 97% and 74% respectively [7].

The research focused on the use of nylon solution for stabilizing soil. Nylons are condensation polymers formed by reacting equal parts of damine and dicarboxylic acid so that amides are formed at both ends of each monomer in a process analogous to polypeptide biopolymers [8]. The nylons are used to produce sachet for packaging potable water for domestic consumption in Nigeria. Once the water is consumed, the bulk of sachet is thrown into surroundings. Being non-biodegradable waste, effort channeled towards recycling it has been on-going but not sufficient to eradicate the entire waste from the environment. The research was embarked upon to provide alternative means of turning waste nylon sachet into useful material for road elements stabilization.

II. Materials and Method

The works involved were in two stages namely preparation of nylon solution and stabilization of soil sample with the prepared solution. The used nylon sachets were collected from open dumpsite located in Ibadan, Nigeria. The collection point coordinates were 03^o 53’ 34.9’’E and 07^o 26’37.6’’N. The collected sachets were washed, air-dried and shredded into smaller pieces to facilitate reaction with solvents. Four solvents namely acetone, toluene, ethyl glycol and dual purpose kerosene (DPK) were procured. Since solubility of any substance is often determined as mass of solid (g) per 100ml of solvent. About 100ml each of four solvents was placed in beaker fitted with thermometer and placed on electric stove. Measured quantity of shredded sachets were introduced into each beaker at specified temperature and stirred until nylon residue was observed and solubility of nylon in solvent was determined. It was discovered that nylon has highest solubility with temperature in DPK solution. Due to DPK availability, moderate cost and of fewer hazards,

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nylon solution of solubility 0.29g/ml obtained from DPK was used in the study.

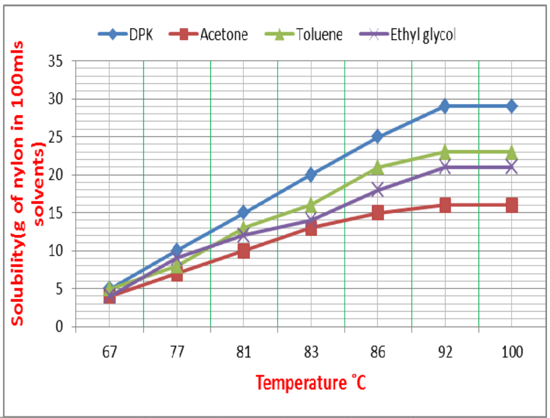
The nylon solution 0.29g/ml rheological properties were measured. The properties were specific gravity at 25^{o}C, penetration test at IP 49/56 and viscosity at 95^{o}C [9], [10] and [11]. Soil sample to be stabilized with nylon solution was obtained from a borrow pit in Ibadan, Nigeria. Preliminary tests such as particle analysis, Atterberg limits and compaction test were carried out for sample identification and its optimum moisture content [12]. Also, the CBR of the unstabilized soil was determined. The soil sample was divided into four parts, preheated individually to 91^{o}C. Part A received 4% by weight of 0.29g/ml nylon solution, part B received 7%, part C received 12% and part D received 16%. Each mixture was hot placed into compaction mold in three layers and compacted and its \CBR was determined [12]. A typical compacted nylon solution stabilized soil is very dense in nature (Fig. 1).

Fig. 1 Molded nylon solution-stabilized soil

III. Results and Discussion

Graphical representation of solubility of nylon in the four solvents was prepared (Fig. 2). The solubility of nylon in DPK solution was the highest and as such further rheological properties of nylon solution of DPK revealed that penetration at 25^{o}C was 93.67mm, viscosity at 600rpm and 91^{o}C was 150cp, and specific gravity at 25^{o}C was 0.99. The soil sample liquid and plastic limits were 22.2% and 14% respectively and its particle size analysis was also presented (Fig. 3). Based on the particle size analysis and Atterberg limits, the soil sample was classified as PS-ML (poorly graded sandy soil). The unstabilized soil CBR was 25.3%. On applying 4% nylon solution, the value dropped to 15.85% and later to 67.78% when it received 16% nylon solution. The complete trend obtained due to addition of nylon solution to the soil sample at different percentages was presented pictorially (Fig. 4).

DPK was the most reliable, affordable and suitable of all the solvents used during the nylon solution preparation. Nylon dissolved easily and at highest rate in DPK. In addition, on hot mixed with soil sample, DPK evaporated very quickly from the mixture. As DPK evaporated, the solution of nylon congealed in form of fibers to hold the soil particles together to make the soil denser. The poor graduation of the soil sample used and presence of organic matter were responsible for the low CBR obtained for unstabilized soil. The CBR of the soil at 4% stabilization was very low because the nylon solution was not sufficient to coat all the soil particles present. Mixture of weak and strong bond was present in the soil matrix. The CBR machine plunger penetrated faster within weak bond zone and at the junction between the two bonds which accounted for the low value of CBR recorded.



	67	77	81	83	86	92	100
DPK	5	10	15	20	25	29	29
Acetone	4	7	10	13	15	16	16
Toluene	5	8	13	16	21	23	23
Ethyl glycol	4	9	12	14	18	21	21

Fig. 2 Solubility (g/100 mls) of nylon in different solvents

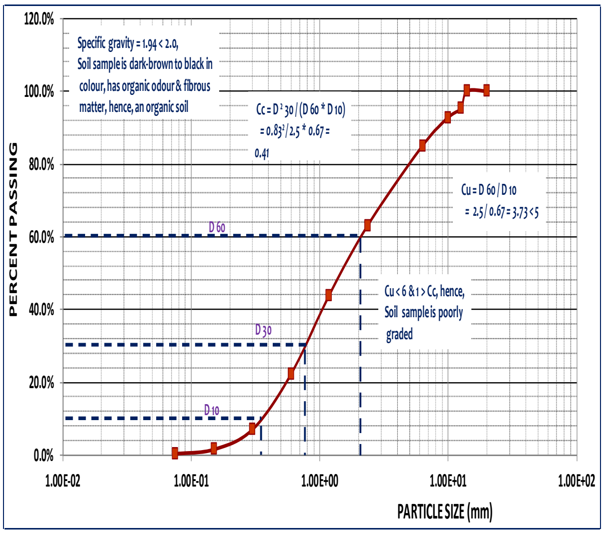


Fig. 3 Soil sample article size curve

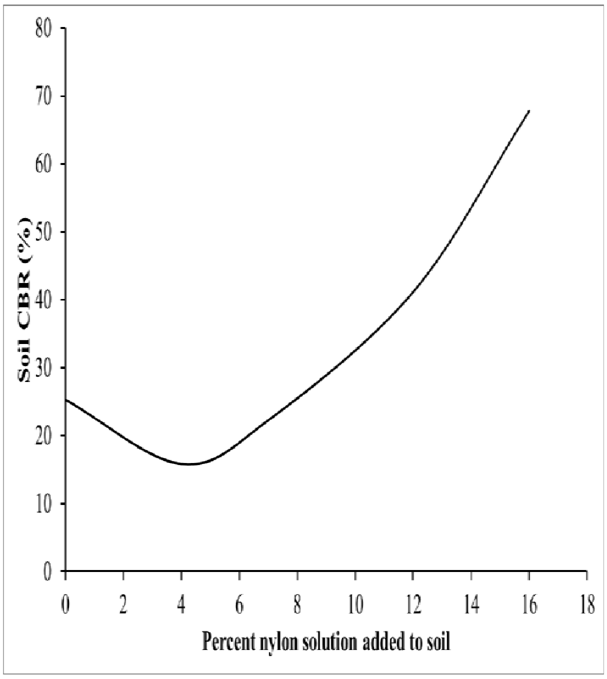


Fig. 4 Soil CBR with respect to percent nylon solution

IV. Conclusion

The study focused on the use of nylon solution obtained from hot mixed nylon in DPK solution as soil stabilizer. The following fact emerged that at very low percentage of stabilization (4%) the value of soil CBR decreased as a result of inadequate nylon solution to aid formation of bond among particles and thereafter increased.

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