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Stabilization of Soil Using Polyacrylamide (PAM) Polymer and its Application in Civil Engineering

Prof. Sayyed Aamir Hussain, Dr. P. P. Saklecha, Vaishnavi Khobragade, Rukshar Ansari, Sajid Saleem, Zeehan Sheikh
Department of Civil Engineering, Anjuman College of Engineering and Technology, Sadar, Nagpur, Maharashtra, India

ABSTRACT

To enhance the properties of soil and reduce the cost of project, polymer was used as an additive for the improvement of a base material of the road work. Polyacrylamide (PAM) is one such polymer which have many advantages including reduction in permeability, an increase in durability and its provision of strength characteristics. It is very cheap and easily available. In the progress of work, 0.02% of polyacrylamide (PAM) polymer is added to the dry weight of black cotton soil. Soil has been collected from Lonara Village (15 km away for Nagpur city). Various index & engineering properties have been tested on treated and untreated samples. The result obtained on both the samples are compared and we get appreciable enhancement in the property of soil. Our main objective is to test the soil on two parameters i.e. improvement in strength and improvement in CBR value of the soil sample. These type of improvement have allow to use the polymer in road construction work.

Keywords: Black cotton soil, Atterberg limits, Consistency, Polymer, In-situ, Polyacrylamide.

I. INTRODUCTION

The quality of material used in road construction and the grain size distribution of the material are very important factor for the work. Soil stabilization is an alteration of soil to enhance their properties. Stabilization can increase the shear strength of soil and control the swell-shrink properties of soil. Black cotton soil is spread in all Nagpur region and is very difficult to deal with the pavement construction work. The base coarse below the pavement should sustain the weight of pavement and reduce the stress due to wheel load to a bearable value. Among other traditional and non-traditional polymers, polyacrylamide have shown an efficient performance in the field work and improve sustainability. The study of polyacrylamide polymer has shown great importance in many construction and industrial projects. The polymer polyacrylamide have very good properties and specific amount of PAM that can increase the strength of soil in the base coarse. Using polyacrylamide on index properties of soil and carrying out two different soil samples and the result is compared. The main objective of this study is to investigate the use of polyacrylamide (PAM) in rural road and evaluate the effects of polyacrylamide on black cotton soil. The outcome of this study will contribute to

improving the knowledge regarding the behavior of PAM treated and help to promote soil for wider adoption by road authorities.

II. Actual work and theory used

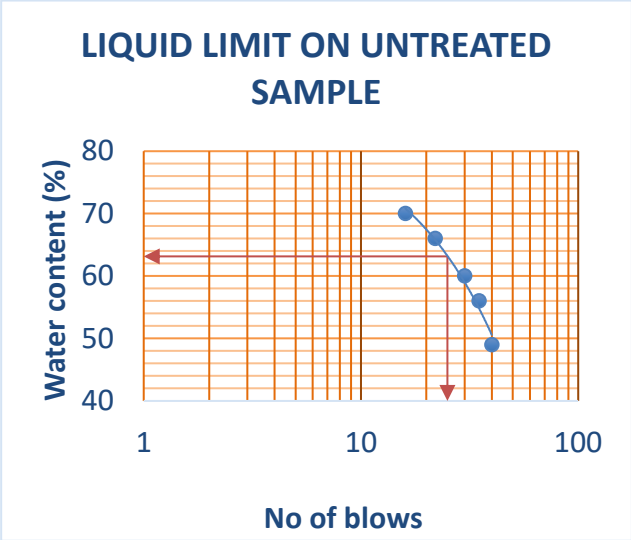
The main aim of any stabilization process is to enhance the product on hand so that it performs better than how it would have in its normal state. In case of soil the stabilization is a very peculiar process, as the soil itself shows a varied degree of properties from place to place. The soil being studied in this particular project is Black Cotton Soil. This soil is considered particularly dangerous for construction purposes due to its tendency to expand and shrink under various environmental conditions. As such, the need for stabilizing it is more pronounced. Though there are various materials available that have been used to stabilize this soil, we have decided to focus on POLYACRYLAMIDE as the stabilizing material and its effects. This material is very cheap and easily available. Besides, the quantity required is also bare minimum. As such it proves to be a good option for undertaking this stabilization process. Preliminary test on the untreated soil sample are conducted to examine its index properties, as the main motive of this paper is to find out whether the addition on PAM in the soil is effective in stabilizing the soil for rural road formation. The index properties of the soil was determined. The determination of water content was carried out by the oven drying method. This method is the most accurate method of determining moisture content if soil. The specific gravity of soil solids may be determined either by a density bottle method or by a pycnometer method. The density bottle method is the most accurate and is suitable for all types of soils, the pycnometer method is used only for coarse grained soils. The determination of particle size of soil grains was done by sieve analysis. Determination of consistency of soil, this term is mostly used for fine grained soils of which the consistency is related to a large extent to water content. The Atterberg limits which are most useful for engineering purposes are liquid limit, plastic limit and shrinkage limit. The maximum dry density and optimum moisture content were determined using proctor test. According to the standards, samples are compacted which involved compacting specimen in five layers using 25 blows per layer. However, based on the results of a previous study on soils treated with PAM as a stabilizing agent, the optimum number of blows was found to be 35 and 45 BPL for these soil type. The CBR test was also conducted in accordance. All this tests were carried out in the laboratory and the results of the same were recorded. Afterwards, the same tests were carried out in the treated soil sample. The PAM was first fixed with water in sealed container at a rate of 2gm per 1liter which created a polymer rate concentration higher than the recommended rate. The amount of PAM to be added was calculated to be as 0.02% of dry weight of soil, as suggested by the supplier. Henceforth, 2gm of PAM was added as solution to 8kg of soil and was properly mixed. The sample was covered so as to allow proper distribution of moisture for 24 hrs. Thereafter the test was performed on this treated sample. The

results obtained are compared to the test result of the earlier soil sample in the natural state.

III. Result

A. Soil in-situ:

The various properties of soil present at the selected site is studied accordingly. Soil shows greater variation enhancement in its strength

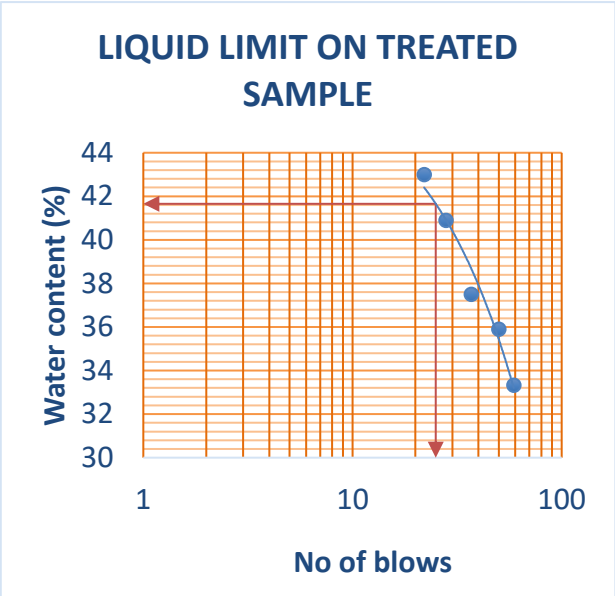


characteristics by the addition of polymer additives. To determine this, various index and engineering properties of soil have been studied and tested as well. The basic in-situ soil is tested in a laboratory without addition of polymer. The test results were as follows:-

Liquid limit of the untreated sample comes out to be 63.15%.

B. Soil after addition of PAM:

Again, we have collected the fresh sample from the same location of the site selected .The excavated soil is sieved from 4.75mm IS sieve. On the other hand, the PAM was first diluted with water in a sealed container at a rate of 2gm per 1liter which created a polymer rate concentration higher than the recommend rate. The treated sample was prepared keeping in mind the concentration used in the research paper we referred (strength and permeability of granular pavement material treated with PAM based additive – Romel N Gargees, Rayya A Hassan, Robert P Evans) to as well as the amount as prescribed by the seller. Hence 2gm of PAM solution was added to the sieved 8kg of soil and mixed properly. The sample was then kept for naturally drying and the test were conducted. The assess to the level of improvement of the fundamental properties of soil were tested by using PAM additive as a stabilizing agent. The sample was covered for 24hrs so as to allow proper distribution of moisture. Finally, after the preparation of treated sample, same index properties and engineering properties were conducted. The test results obtained were as follows:-



The liquid limit of soil comes out to be 41.655% with treated sample.

We set out to test the soil on two parameters to check the effects of the polymer on the soil properties and we successfully established that the soil was stabilized on addition of PAM in the dosage of 0.02% of its dry weight. The next step involves establishing the feasibility of this polymer stabilized soil as a sub-grade material, to conduct engineering test on the sample.

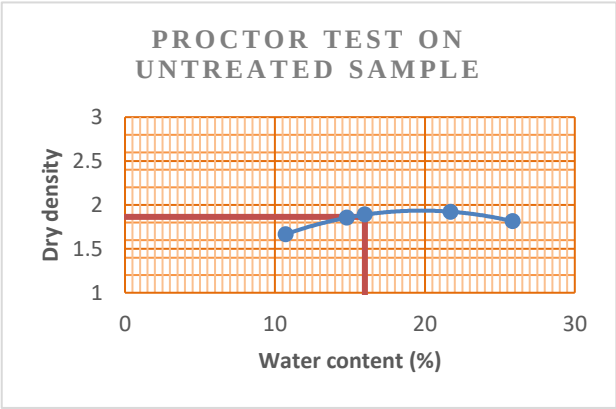
C. Engineering test performed

i. Unconfined compression test

Unconfined compression strength testing was performed to assess the effect of using PAM on the UCS of the stabilized sample of soil. The test was performed using hydraulic loading machine for treated as well as untreated soil sample. At least five Specimen were prepared in order to ensure reliable results. The UCS values of treated and untreated sample are presented in figure. It is to be noted that the strength of sample both untreated and treated presented in the figure below is the average UCS value of 5 specimen per sample. A systematic increase in the strength value was observed for all 5 soils treated with PAM when compared to their untreated counterparts. Fig shows that the level of improvement is influenced by soil type. The increase in UCS strength of the soil would significantly influence pavement design thickness and ultimately increases pavement capacity to load distribution.

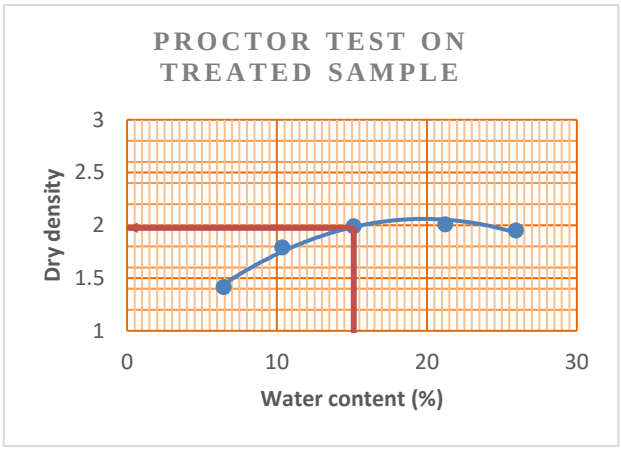
ii. Standard proctor test

The value of maximum dry density (MDD) and optimum moisture content (OMC) on the treated and untreated soil sample were obtained. At least five specimen were prepared and tested under



light compaction. The average of the observation were taken and the results were recorded as below:-

Result:- The MDD= 1.864 and OMC =16.0%

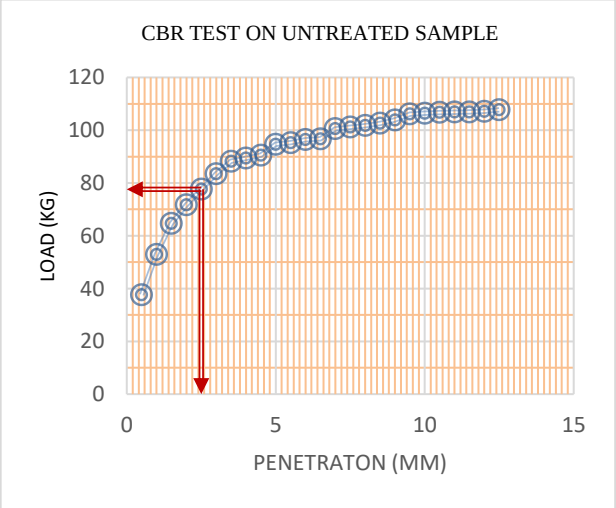


Result:- The MDD=1.976 and OMC=15.12%

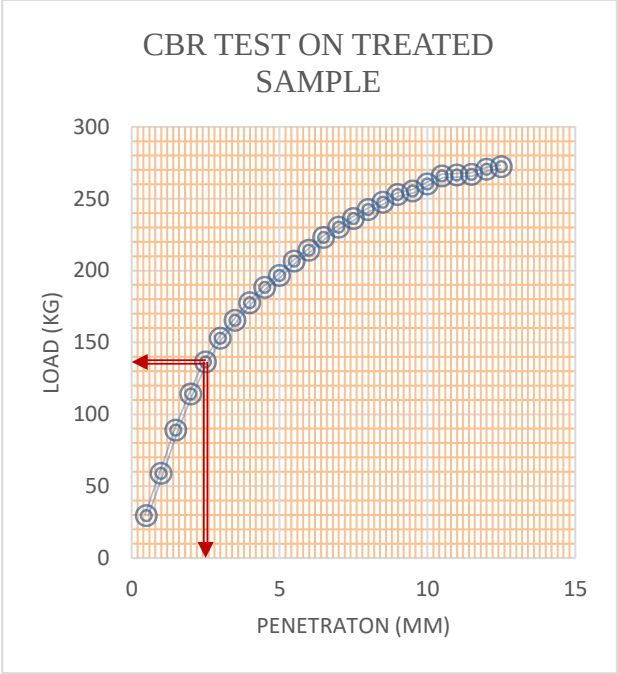
The MDD & OMC value were ploted on the graph and the vast comparative results were observed .PAM significantly enhances and rapidly increases the density and shear strength bearing capacity of the soil. The compaction curve graph of the treated and untreated value of the sample were ploted as follows:-ss

iii. CBR test

This study used CBR testing to evaluate the effects of using PAM on the bearing capacity of the stabilized sample of soil. This was conducted using a hydraulic loading machine for all treated and untreated samples. Three samples were prepared per sample i.e untreated and treated in order to ensure reliable results. The average specimen value were shown in fig:-



The CBR of untreated sample is 5.23%.



The CBR of treated sample is 9.9%.

D. Comparative Results

After performing, the atterberg's limit and various engineering test on the treated and untreated soil sample, we observe drastic increase in the properties of soil. Soil strength increases which is very beneficial for black cotton soil. These increase in characteristics prone to use PAM as an additive which give successful results. The comparative results between the treated and untreated samples whereas follow:-

SR.NO	TEST PERFORMED	UNTREATED SAMPLE	TREATED SAMPLE
1	Water content	6.53%	7.61%
2	Permeability	2.56%	5.55%
3	Liquid limit	56.69%	41.655%

4	Plastic limit	20.3 6%	21.9%
5	Optimum moisture content	16.0%	15.12%
6	Maximum dry density	1.864	1.976
7	CBR value	5.23%	9.9%

IV. Conclusion

Based on the experimental investigations on stabilization of soil we conclude that the sub – base strength of the rural roads is increased by addition of PAM in the soil. By practically adopting this proportion of polymer in the soil in the construction of rural road techniques subsequent results can be obtained. Due to this the construction activity cost of the rural road construction will be reduced with the increased life.

Hence we conclude that the soil mixed with 0.02% by dry weight of the soil can be used as a good subgrade stabilization agent, to enhance the performance of the flexible pavement, which can be beneficial in the formation of rural roads.

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