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STUDY ON STABILIZERS FOR GRANULAR LAYERS OF FLEXIBLE PAVEMENTS: A REVIEW

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ABSTRACT

Highways plays a vital role in the development and progress of any nation, which provides them access to the resources and interconnection between countries, states and cities. India is known to have one of largest highway network in the world, which transports approximately 64.5% of goods all over the country and 90% traffic passengers of the country, who uses this network to commute. The total expenditure allocated by the Ministry of Road Transport and Highways for 2023-2024 is Rs. 2.7 lakh crores, which is 36% higher than 2022-2023(1.99 lakh crores). All we need now a day is the economical and engineering approach technique to enhance durability and life of the existing roads/ highways. This study is a review of application of stabilizers for Granular Sub Base of Flexible Pavements. The main objective of this study to determine Unconfined Compressive Strength, Elastic Modulus of stabilized material prepared with different stabilizers for use in Cement Treated Sub Base (CTSB), determine optimum dose of various Stabilizers with or without cement to achieve desired strength of Cement Treated Sub Base (CTSB) and to determine the durability characteristics of the samples prepared at optimum dose. This paper deduces that many researchers used different stabilizers such as pumice, fly-ash, lime stabilized fly-ash, combined cement and bitumen emulsion, which were found suitable and effective to achieve required strength for the flexible pavements.

Keywords: Stabilizers, Cement Treated Sub Base (CTSB), Flexible Pavement.

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I. INTRODUCTION

Highway plays a vital role in connecting us with our day to day life needs, and any country's progress and economy depends on the ease of access and usage. The strength and integrity of highways deteriorates with the passage of time. Government makes huge expenditure for the maintenance or at times reconstruction of old highways. Stabilization of Granular Sub Base of flexible pavement is engineering approach which allows old highways to regain and enhance its strength, which is depleted over the years. Use of stabilized Granular Sub Base of flexible pavement reduces the cost of construction of new highways and enables use of existing materials. Many stabilizers such as pumice, fly-ash, lime stabilized fly-ash, combined cement and bitumen emulsion are found efficient to achieve the required strength for the flexible pavements.

II. TYPES OF PAVEMENTS

There are two types of pavements used in India. Following are mentioned below

- Flexible Pavements
- Rigid Pavements

In flexible pavements consists of bituminous surface over base course and sub-base course. The structural strength of flexible pavement can be attained by the combination of different layers of the pavement. These pavements have negligible flexure strength.

In rigid pavements are named rigid because they have high flexure strength rigidity and very less deflection due to high modulus of elasticity of their surface course, it is usually laid in cement concrete.

III. STABILIZATION OF FLEXIBLE PAVEMENTS

Stabilization is an engineering approach by which flexible pavements can re-gain its lost its strength by adding stabilizers such as different types of chemicals, fly-ash, lime, cement or a combination of cement and chemicals and emulsion etc. mixed and blended with soils to achieve desired gradation and strength. This concept was extended to sub base layers and base layers to strengthen these to meet the requirements of high strength for runway pavements. The technology has now got a place in roads for following reasons:

(i) The existing granular layers can be strengthened by in-situ recycler with addition of Stabilizer and Cement; thus minimizing wastage and reducing period of construction.

(ii) There is less consumption of aggregate as the technology enables construction possible with less thickness.

(iii) The overall cost may even reduce.

IV. NEED AND SCOPE OF STUDY

Many researchers used different stabilizers such as geo-synthetic, pumice, fly-ash, lime stabilized fly-ash, combined cement and bitumen emulsion, which were found suitable and effective to achieve required strength to flexible pavements. In this study use of some commonly used stabilizers like RBI 81, Geocrete and their combination with cement will be used and their effectiveness will be checked to achieve required strength to the flexible pavement, which further can be used on existing flexible pavements.

V. OBJECTIVE OF STUDY

1. To study the concept and importance of Cement Treated Sub-base.
2. To study the effect of using Cement treated Sub-base/Base on crust thickness in Highway Pavement. (Reduction in Crust thickness i.e. WMM, DBM layer).
3. To determine the Unconfined Compressive Strength of samples for use as CTSB prepared with different stabilizers e.g. RBI-81, Geocrete with different doses and combination with Cement.
4. To determine optimum dose of the stabilizer and perform durability test on it.
5. To compare the performance, required dosage and relative cost of stabilizers for use as CTSB.

VI. LITERATURE REVIEW

Saltan, Mehmet et.al (2007) [1] in his study, he reviewed the usability of the pumice of the Isparta - Karakaya those categorized in the light aggregate class, have been examined in terms of stabilization material in the subbase considering volumetric unit weight. Initially, the physical properties of lightweight aggregate material have been analyzed. It has also been researched if it is possible to use in a subbase layer or not. For the research, few experiments have been carried out by using experiment samples such as stability to freeze, solidity, strength, Atterberg limits and California Bearing Ratio (CBR). The usability of the stabilization material has been determined in the subbase layer. As the result of the experimental research, it has been observed and determined that pumice can be used as subbase material of highway and the stabilization material.

Mantri, Anjan Kumar et.al (2009) [2] In the present work an attempt was made to use fly-ash, lime stabilized fly-ash, cement stabilized flyash and lime-cement stabilized fly-ash as subbase course in flexible pavement system. Off-lane test tracks were constructed in the JNTU Engineering college campus, Kakinada, with different alternatives on expansive soil subgrade and in-situ tests were carried out immediately after the wet season. Result of experiments showed load carrying capacity of the flexible pavement system was significantly increased for lime-cement stabilized fly-ash subbase stretch with respect to the fly-ash subbase stretch on expansive soil subgrade. Maximum reduction in heave values were obtained for the lime-cement stabilized fly-ash subbase stretch compared to other stretches on expansive soil subgrade.

Marandi, S.M et.al (2009) [3] analyzed the use of combined cement and bitumen emulsion in base course stabilization in details and examine its replacement with conventional pavement in regions with low quality materials and limited construction period. To conduct the objectives, the research divided into three phases. Phase I involved the optimization of cement and bitumen emulsion. In this case, a series of Indirect Tensile Strength (ITS), Unconfined Compressive Strength (UCS) and Marshall Tests were carried out. In the second phase, various alternative roadway sections examined for minimizing the pavement thickness and increasing the bearing capacity and finally in third phase, a Falling Weight Deflectometer (FWD) machine used to examine the pavement bearing capacity for three sections of the roadway. It was found that, the optimum values to eliminate the creation of shrinkage cracks in the whole project and minimize the execution period and construction costs were 3% for both binders in stabilization and its replacement with conventional pavement method (i.e., stabilized layer with conventional sub-base and base layers).

Mantri, Anjan Kumar et.al (2012) [4] has made an attempt to use lime stabilized fly-ash subbase course in model field pavement stretches. Cyclic plate load tests are conducted on fly-ash subbase and on lime stabilized fly-ash subbase stretches but instead of fly-ash, lime stabilized fly-ash is used as subbase material. Based on the laboratory soaked CBR tests 8% lime, giving 20% CBR is used for preparation of lime stabilized fly-ash layer. Accordingly, 8% of lime is mixed separately with fly-ash in dry state and then water is added to the mix corresponding to OMC and the mix is laid in three layers of 5cm compacted thickness to a total thickness of 15cm. Each layer is compacted to MDD using hand operator roller. After sufficient curing of the subbase, 15cm thick compacted Base course is laid.

Mojtaba, Shojaei Baghini et.al (2015) [5] has reviewed that the Freeze-thaw (FT) cycles and moisture susceptibility are important factors influencing the geotechnical characteristics of soil aggregates. Given the lack of published information on the behavior of cement-bitumen emulsion-treated base (CBETB) under environmental conditions, especially freezing and thawing, this study investigated the effects of these additives on the CBETB performance. The primary goal was to evaluate the resistance of CBETB to moisture damage by performing FT, Marshall conditioning, and AASHTO T-283 tests and to evaluate the long-term stripping susceptibility of CBETB while also predicting the liquid anti stripping additives to assess the mixture's durability and workability. Specimens were stabilized with Portland cement (0%–6%), bitumen emulsion (0%–5%), and Portland cement-bitumen emulsion mixtures and cured for 7 days, and their short and long-term performances were studied. Evaluation results of both the Marshall Stability ratio and the tensile strength ratio show that the additions of additives increase the resistance of the mixtures to moisture damage. Results of durability tests performed for determining the resistance of compacted specimens to repeated FT cycles indicated that the specimen with the 4% cement- 3% bitumen emulsion mixture significantly improves water absorption, volume changes, and weight losses. This indicates the effectiveness of this additive as a road base stabilizer with excellent engineering properties for cold regions.

Chaudhary, P.M et.al (2016) [6] has reviewed that the PMGSY scheme launched in late nineties was aimed to provide all weather road connectivity to the rural habitations for improving their socio-economic conditions as well as accessibility to education, medical facilities and market places. In many areas, under the prevailing conditions of soil, climate and traffic, it was observed that most of the roads suffer from premature failure in terms of heavy deformation, cracking, rutting & stripping. Therefore, it was felt appropriate to treat the problematic sub-grade soil as well as providing sub-base of locally available material treated with non-conventional materials while designing the flexible pavements in order to achieve twin objectives of durability and economy of pavement construction and maintenance. Accordingly, total six rural road sections are selected for sub-grade and sub-base stabilization with the use of lime, lime & fly-ash and lime & sand. Design of the mix has been carried out collecting the soil samples from the field and conducting index property, Free Swell Index (FSI) and CBR tests in the laboratory. The optimum proportion of lime is found in the range of 3 % to 5 % and that of fly-ash is 15%. The sub-grade CBR is found to increase from less than 3% to more than 10% and FSI reduced from more than 50% to less than 20%. Required sub-base of 300mm is provided in two layers of lower sub-base of soil treated with 5% lime and fly-ash and upper sub base of GSB; each of 150mm thickness. Saving of Rs.424 per cum of sub base is achieved through this. Overall, the cost of pavement construction has reduced by 3-5% of the total cost of pavement.

Mamun, Md. Mahmud Hasan et.al (2016) [7] reviewed that the purpose of a stabilized base or sub-base layer is to provide a transitional load-bearing stratum between the pavement layer, which directly receives the wheel loadings of vehicular traffic, and the underlying sub-grade soil. Stabilized base or sub-base materials may be used to provide support for either flexible or rigid pavements, but are more frequently used with flexible pavements. The key to strength development in stabilized base or sub-base mixtures is in the matrix that binds the aggregate particles together. The strength of the matrix is affected by the cementations material used in the mixture. The amount of cementations material in a stabilized base or sub-base mix usually ranges from 5 to 10 percent by weight of the mix.

Prasad, Saket et.al (2016) [8] did the research work to develop a pavement design chart using cement and lime stabilized base for rural roads with light to medium traffic (traffic volume up-to 5 million standard axles). Cement stabilized layers was used in service roads of NH 50. Service road of 22.6 Km was constructed using Cement treated base and sub-base layers. Not only it saved money but also helped to increase life cycle of road. Granular bases can carry less tonnage of loads but can withstand more tonnage of loads. As design tonnage increases cost increases in Granular bases but not in the case of cement treated bases. When traffic is diverted from main Carriageway to Service road due to maintenance, cement treated bases can withstand more traffic load as compared to granular bases. CTB can handle leakage of water from other sources due to its good drainage properties.

Improved Performance in Rutting and Fatigue cracking compared to un-stabilized granular base to cement treated base. It resists cyclic freezing, rain, and spring-weather damage, when compared with granular base of service road. Cement-treated base continues to gain strength with age even under traffic, when compared.

Emmert Fabiano et.al (2017) [9] evaluated the chemical stabilization of soils with cement toward application in improving forest roads, as constructive alternative of low cost. The study was carried out with fine soils from the region of Niquelândia-GO, where the sand-clay-silt particle proportion was predominant, and Portland cement CP-II-Z-32 used as a stabilizing agent at 2% under dry soil weight. Geotechnical tests were conducted in different compaction energies (normal, intermediate and modified) and curing periods (1, 7 and 28 days), and the data were analyzed statistically by Analysis of Variance (ANOVA) and Tukey test. The soil-cement mixture presented higher unconfined compressive strength (UCS) than the compacted local soil, reaching a highest value of 650.52 kPa on modified compaction energy. Also, California bearing ratio (CBR) with values of 44.1% in the intermediate compaction energy and 41.7% in the modified compaction energy reached higher values compared to lateritic soil sampled. Soil-cement mixture was prescribed as improved layer for forest road surface, as well as reached indication for subgrade reinforcement material and sub-base in conventional paved roads.

Prasad, P.S. et.al (2018) [10] carry out the studies, soil sample from Krishnapatnam Port, Andhra Pradesh was collected by the client and supplied to CSIR -CRRI. The physical and engineering properties such as grain size analysis, Atterberg limits, Free swell index (FSI), modified Proctor's density and California Bearing Ratio (CBR) of native (unstabilised / untreated) soil samples were determined as per Bureau of Indian Standard (BIS) code/specifications. Also to assess the geotechnical characteristics of stabilised soil, the collected native soil was mixed with cement and Stabilroad Stabilizer and its strength was evaluated in terms of unconfined compressive strength (UCS) and California bearing ratio (CBR).

Singh Sanjay, et.al (2019) [11] studied the reasons of failure of flexible pavements in India. also the conventional materials used for the construction of layers in flexible pavements. The cement treated bases and sub-bases are studied. The unconfined compressive strength for the various combinations of cementitious materials to be added in GSB material is checked and its performance is compared with the traditional method of construction of flexible pavements. Comparison is done on the basis of following factors:

A. Quantity of materials required: The quantity of materials required for construction of 1 Km long and 7.5 m wide highway with CTB/CTSB method and traditional method is compared.

B. This chapter briefly summarizes the findings of studies performed at the Center for Highway Research and by other investigators in two major areas pertaining to cement-treated materials: factors affecting the tensile strength of cement-treated soil and shrinkage characteristics of cement-treated base materials. In addition, two mix design procedures are reviewed. The findings concerning tensile strengths are evaluated in more details.

Phatangare Sagar T. et.al (2017) [12] studied the concept of CTB/CTSB in this thesis. The effects of using CTB/CTSB rather than the traditional base/sub-base materials are also studied. The comparison of both types of pavements construction methods is done and the factors affecting for performance of pavements of road are also studied.

VII. CONCLUSIONS

1. Based on review of work by many researchers it is established that different stabilizers such as, pumice, fly-ash, lime stabilized fly-ash, combined cement and bitumen emulsion are found suitable and effective to achieve required strength to flexible pavements.
2. There is need to carry out more experimental studies using stabilizers available in Indian market to have a broad data base for ease of adoption of these.

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