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FLEXIBLE PAVEMENT DESIGN AND ITS COAST ELEVATION

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Abstract— As a civil engineer one has to think differently. For a good road, the good pavement is necessary. In this project we are considering the flexible pavement by using a mixture of different materials and also we are analyzing the traffic volume. The flexible pavement design is done using AASTHO method and IRC method. We are implementing the flexible pavement in the newly construction road i.e, kadapa to Kurnool alternatively. We are proposing different materials in the wearing coat layer like untreated soil, clay material and lime stabilized. Estimation is also carried out in this project for various combinations of the materials and thereby proposing a better choice. The data used in this project such as a type of soil, the thickness of soil and the traffic data were obtained from KMC constructions, kadapa. The estimations show a reduction in the cost of construction of flexible pavement by about Rs. 50,000 as proved in our project.

I. INTRODUCTION

Transportation contributes to the economic, industrial, social and cultural development of any country. Transportation is vital for the economic development of any region since every commodity produced whether it is food, clothing, industrial products or medicine needs transport at all stages from production to distribution. Ideal transportation improves personal mobility, reduces travel time, an increase of goods they lower the production and distribution tending to national economic growth. High way development programs opens up new avenues in employment, agriculture, industry, commerce and health by inherent virtue of being a communication and transport between the developed and under developed areas. A pavement is a structural system composed of layers of appropriate materials resting on natural sub grade or on the embankment. The chief function s of a pavement are to provide a smooth wearing surface with a suitable color and texture to withstand wear and tear, weathering due to harmful agents and Efficiently transmit the stresses produced by traffic loads to the underlying ground.

The design of pavement consists of two different phases, the determination of the thickness of pavement layer(s) having certain mechanical properties and the determination of the composition of the materials that provide these properties. The flexible pavement consists of number of layers viz. surface course, base course, and sub base course .the load carrying capacity of flexible pavement depends upon the load distribution characteristics of different layers, and mode of load transfer is by distribution of the wheel load stresses through wider area. Hence, the magnitude of wheel load stresses is minimum at lower layers and the superiority of materials decreases from top to bottom. Black Cotton (BC) soils are highly clayey soils, grayish to blackish in color found in several states in India. In several BC soil areas suitable road aggregates are to be transported from distant places, thus increasing the cost of conventional type of pavements. Typical behavior of these soils under different climatic conditions has made the construction and maintenance of roads not only expensive, but also difficult. The pavements constructed in BC soil areas are found to suffer from early failures. In flexible pavements with heavy traffic excessive unevenness, ruts, waves and corrugations are formed almost after every monsoon season, resulting in heavy cost of maintenance demand every year. In this work an attempt is made to compare the designs of the flexible pavement based on IRC (Indian Roads Congress) and AASTHO methods, constructed on treated and untreated subgrade soil. A comparative economic analysis is also made between these pavements.

II. LITERATURE REVIEW

The surface of the roadway should be stable and non –yielding, to allow the heavy wheel loads of road traffic to move with least possible rolling resistance. The road surface should also be even along the longitudinal profile to enable the fast vehicles to move safely and comfortably at the design speed. The earth road may not able to fulfill any of the above requirements, especially during the varying conditions of traffic loads and the weather. At high moisture contents, the soil become weaker and soft and starts yielding under heavy wheel loads, thus increasing the tractive resistance. The unevenness and undulations of the surface along the longitudinal profile of the road causes vertical oscillation in the fast moving automobiles, increasing the fuel consumption and the wear of the vehicle components, resulting in a considerable increase in the vehicle operation cost. Apart from this uneven pavement surface causes discomfort and fatigue to the passengers of the fast moving vehicle and cyclists. Therefore, in order to provide a stable and even surface for the traffic, the roadway is providing with a suitably designed and constructed pavement structure. Thus a pavement consisting of few layers of pavement materials is constructed over prepared soil sub grade to serve as a carriageway.

The pavement carries the wheel loads and transfer the load stresses through a wider area on the soil sub grade below. Thus the stresses transferred to the sub grade soil through the pavement surface. The reduction in the wheel load stresses due to the pavement depends both on its thickness and characteristics of the pavement layers. A pavement layer is considered more effective or superior, if it is able to distribute the wheel load stress trough a large area per unit depth of the layer. However, there will be small amount of temporary deformation even on a good pavement surface when heavy wheel loads applied. One of the objectives of a well –designed and constructed pavement is therefore to keep this elastic deformation of the pavement within the permissible limits, so that the pavement can sustain a large number of the repeated load applications during the designed life. Based on the vertical alignment and the environmental conditions of the site, the pavement may be constructed over an embankment, cut or almost at the ground level itself. It is always desirable to construct the pavement well above the maximum level of the ground water to keep the sub grade relatively dry even during the monsoons.

A. CONVENTIONAL FLEXIBLE PAVEMENTS

Conventional flexible pavements are layered systems with better materials on top where the intensity of stress is high and inferior materials at the bottom where the intensity is low. Adhesion to this principle makes possible the use of local materials and usually results in a most economical design.

a. Seal Coat

Seal coat is thin asphalt surface treatment used to water proof the surface or to provide skid resistance where the aggregate in the surface course may be polished by traffic and become slippery.

b. Surface Course

The surface course is the top course of a flexible pavement, sometimes called wearing surface**.** It is usually constructed by using dense grade HMA. It must be tough to resist distortion under traffic and provide a smooth skid resistant riding surface. It must be water proof to protect the entire pavement and subgrade from the weakening effect of water. If the above requirements cannot be met the use of seal coat is recommended.

c. Binder Course

It is the asphalt layer below the surface course. Binder course is used for two reasons:

1. HMA is too thick to be compacted in a single layer, so that it must be placed in two layers.
2. The binder course generally consists of larger aggregates and less asphalt and does not require as a high quality as a surface course. So replacing a part of the surface course by binder course results in a more economical design.
3. If the binder course more than 3 inches, it is placed in 2 layers.

d. Track Coat and Prime Coat

A tack coat a very application of asphalt, usually asphalt emulsion diluted with water, used to ensure a bond between the surface being paved and the overlying course. The three essential requirements of a tack coat are that it must be very thin, and it must be allowed to break or cure before HMA is laid. A prime coat is an application of low-viscosity cut back asphalt to an absorbent surface, such as untreated granular base on which an asphalt layer will be placed. Its purpose is to bind the granular base to the asphalt layer. The difference between a tack coat and a prime coat is that the tack coat does not require the penetration of asphalt into underlying layer, plugs voids, and forms a water tight surface. Although the type of asphalt used are quite different, both are spray applications.

e. Base Course and Sub base Course

The base course is a layer of material immediately beneath the surface or binder course. It may be composed of crushed stone, crushed slag, or other untreated or stabilized materials. The reasons that two different granular materials are used are for economy. Instead of using the more expensive base material for the entire layer, local and cheaper materials can be used as a sub base course on the top of sub base course on the top of the sub grade.

f. Subgrade

The top 500mm of sub grade should be scarified and compacted to the desirable density near the optimum moisture content. This compacted subgrade may be the in-situ or a layer of a selected material.

B. FULL- DEPTH ASPHALT PAVEMENTS

Full-depth asphalt pavements are constructed by replacing one or more layers of HMA directly on the subgrade or improved subgrade. This concept was conceived by the Asphalt Institute in 1960 and is generally considered the most cost-effective and dependable type of asphalt pavement for heavy traffic. This type of construction is economical in areas where local materials are not available. It we more convenient to purchase only one material, i.e. ., HMA, rather than several materials from different sources, thus minimizing the administration and equipment costs. Figure below shows a typical

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cross-section of a full depth asphalt pavement. The asphalt base course in the full -depth asphalt pavement construction is same as the binder course in conventional pavement. Similar to conventional pavement, a tack coat must be applied between asphalt layers to bind them together.

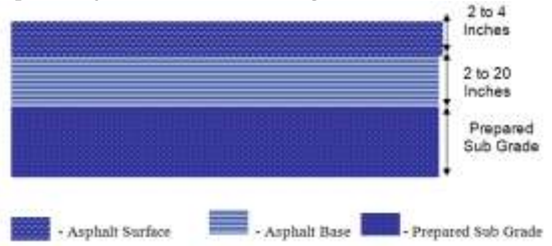

Fig.1: Typical Cross-Section of a Full-Depth Asphalt Pavement

The full depth asphalt pavements have the following advantages:

a) They have no permeable granular layers to entrap water and impair performance.
b) Time required for construction is reduced.
c) On widening projects, where adjacent traffic must usually be maintained, full-depth asphalt pavements can be especially advantageous.
d) They provide and retain uniformity in the pavement structures.
e) They are less affected by frost or moisture.
f) According to limited studies, moisture content does not build up in subgrade under full-depth asphalt pavement structures as they do under pavements with granular bases. Thus there is little or no reduction in subgrade strength.

C. CONTAINED ROCK ASPHALT MAT (CRAM) PAVEMENTS

Another type of construction is the Contained Rock Asphalt Mat (CRAM), which is composed of four layers. Starting from bottom, a modified dense HMA layer is spread over a conventional prepared subgrade followed by a layer of open–graded aggregate, then a dense graded aggregate and finally a dense-graded HMA varying surface as shown in the figure.

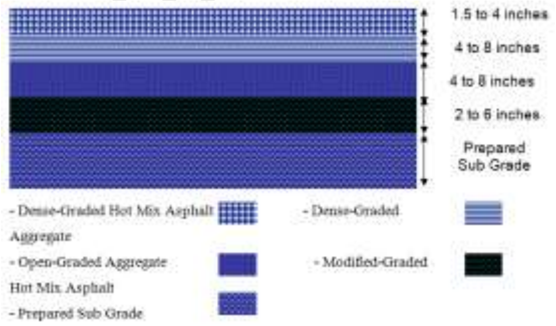

Fig.2: Typical CRAM Section

A major advantage of CRAM construction is that the bottom asphalt layer significantly reduces the vertical compressive strain on the subgrade and the horizontal tensile stress in the overlying granular layer. The reduction of tensile stress in the granular material makes it stronger and thus the tensile stress and strain in the asphalt surface layer. Benefits of CRAM section include

a) Controlling surface water via the open-graded aggregates
b) Preventing the contamination of aggregates by the infiltration of subgrade soils
c) Improving fatigue resistance of bottom asphalt layer by the possible use of softer asphalts and reducing crack propagation due to a more favorable distribution of tensile stress and strain in the surface layer.

III. DIFFERENT TECHNIQUES TO IMPROVE EXPANSIVE SOILS

Cost effective roads are very vital for economical growth in any country. There is an urgent need to identify new materials, improve road construction techniques to expand the road network. Commonly used materials are fast depleting and this has led to an increase in the cost of construction, hence, the search for new materials and improved techniques to process the local materials has received an increased impetus. When poor quality soil is available at the construction site, the best option is to modify the properties of the soil so that it meets the pavement design requirements. This has led to the development of soil stabilization techniques. Since the nature and properties of natural soil vary widely, a suitable stabilization technique has to be adopted for a particular situation after considering the soil properties. Soil improvement by mechanical or chemical means is widely adopted. In order to stabilize soils for improving strength and durability, a number order to stabilize soils for improving strength and durability, a number of chemical additives, both inorganic and organic, have also been used.

The various options to increase the strength and minimize heave in expansive soils are

a. Avoiding expansive material
b. Mechanical, physical or chemical alteration.

Avoiding the expansive soil in favour of a safer foundation soil is not an economically viable proposition in most of the situations. With the development of several modern techniques for effectively combating problems posed by expansive soils, it is seldom adopted these days. In mechanical alteration, excavation of expansive soil and replacement with non-expansive material. Where the depth of active zone is small and where a suitable replacement is available.

In the chemical alteration involves addition of chemicals to expansive clay to increase the strength and reduce heave by altering the nature of clay minerals. Of all the chemicals tried. Lime is the most effective and economical additive. The all the chemicals tried, lime is the most effective and economical additive. The technique has a limitation that only top few layers of the soils are modified. In pavements, a technique called lime-slurry pressure injection (LSPI) is used where lime-study into the drilled-holes under a pressure of 15kg/cm^2. Lime or lime-soil columns were also tried to stabilize expansive clay in-situ (sriramarao, 1984. It has been reported (venkatakratnam et al,1985, Babu Shankar et al,1989) that diffusion of lime is effective up to a radial distances of about 3 times the diameter of the lime-soil column.

A. STABILIZATION:

Soil stabilization in the broadest sense, is the alteration of any property of a soil to improve its engineering performance. Soil stabilization is only one of several techniques available to the soil engineer and its selection for any problems should be made only after a comparison with other techniques shows it to be the best solution to the problem. Most of the work of stabilization of black cotton soil has been carried out so far, by using lime, cement and fly ash. The presence of lime in small quantities of about 1% to 4% by weight will improve properties like plasticity and strength. The addition of cement improves the strength of the cement considerably.

From stabilization point of view, the following are the problem in the case of black cotton soils.

1. There is excessive variation in volume and stability with variation in water content.
2. It is very difficult to pulverize the soil as the dry strength and the wet soil is too sticky and unmanageable.

The field of stabilization is quite vast. The various methods adopted for stabilization can be grouped broadly as under.

1. Mechanical Stabilization
2. Thermal Stabilization
3. Chemical Stabilization
4. Bituminous Stabilization

Generally Black cotton soil is stabilized with chemical admixture, as other methods are found to be not very effective.

Studies have been carried out in this investigation to study the strength characteristics of lime-cement stabilized soil mixes. The expansive soil is collected from Stabilization of soil has been done with the help of different percentages of lime-cement combinations. CBR test have been carried out by lime content between 0 to 7 %.

B. LIME STABILIZATION

Soil lime stabilization has been widely used either as a modifier for clayey soil or as a binder. In several cases both actions of lime may be observed. When clayey soils with high Plasticity Index is decreased and soil becomes flexible and easy to be pulverized, having less affinity with water. All these modifications are considered desirable for stabilization work. Lime also imparts some binding action even in granular soils. In fine grained soils there can be puzzolonic action resulting in added strength.

Herrin and Mitchell presented in 1961 a summary of the knowledge till then on lime-soil mixtures and this was accompanied bibliography of articles on the subject from 1925 to 1960. A short resume on the subject by (Uppal and Pali, 1960) appeared about the same time in the Indian Roads Congress journal, with a brief account of the research findings of India.

The lime available in different parts of country varies widely in its chemical composition. Depending on the variation in chemical composition, the different limes have been classified as clacitic, dolomitic and hydraulic limes. A review of research work carried on India and abroad indicates that the addition of these limes improves considerably the physical properties and strength properties of clays. The improvements in these properties of soils are however, dependent on various factors such as soil type, quality and quantity of limes density of compaction, curing period, etc.

Addition of lime, particularly to clayey and silty soils, improves the strength characteristics. Simplicity, economy and efficiency are the chief advantages of soil stabilization using lime. Several investigations (IRC Special Report, 1976; R.K.Katti, K.Kulakarni, 1966) have dealt with the aspects of improvement on the Physical and Engineering properties of clayey soils treated with lime.

The optimum lime content required to improve the properties of soil(reduction in plasticity and increase of strength)has been found to vary between 3% and 10% depending on the type of oil. The optimum lime content for the maximum strength is not a static value, but varies considerably with the amount of clay, type of clay minerals present, curing period, curing temperature. For the soils in the coastal region of Andhra Pradesh, this optimum lime content is observed to be about 5 percent (Ramana Sastry et al, 1986 , Sastry et al , 1987) . The development of strength is due to an increase in angle of internal friction of the soil. This is due to the result of the information of cementitous products during puzzolonic reactions and the effect of aggregation resulting in greater interlocking and rougher surfaces.

IV. FLEXIBLE PAVEMENT DESIGN

The purpose of pavement is to provide a functional surface for the safe operation of vehicle.

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The pavement is to be designed such that the functional requirements are fully satisfied. An optimum design must balance the total cost against the performance of pavement construction. The most efficient design should be have minimum total cost which includes initial construction costs, maintenance costs, operation costs and the cost of contingencies.

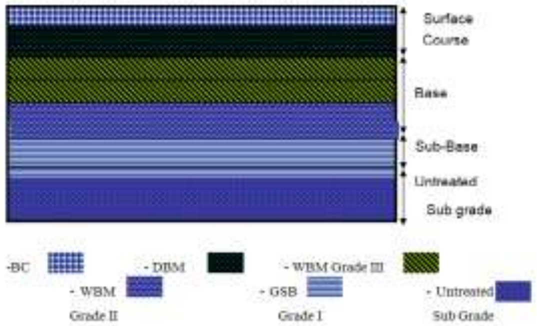

Fig.3 Composition of flexible pavement on untreated clay sub grade

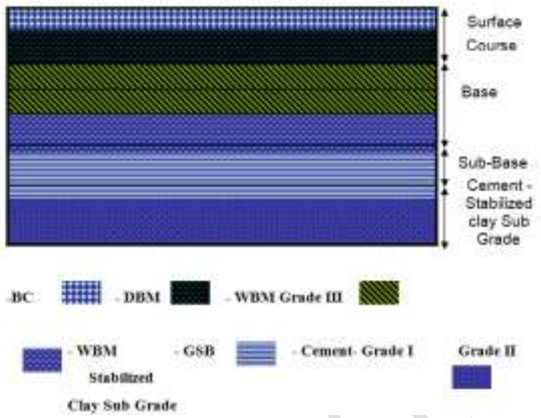

Fig.4 Composition of flexible pavement on Cement-Stabilized clay sub grade

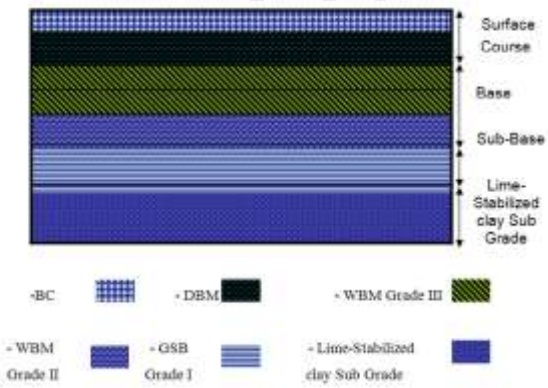

Fig.5 Composition of flexible pavement on Lime-Stabilized clay sub grade

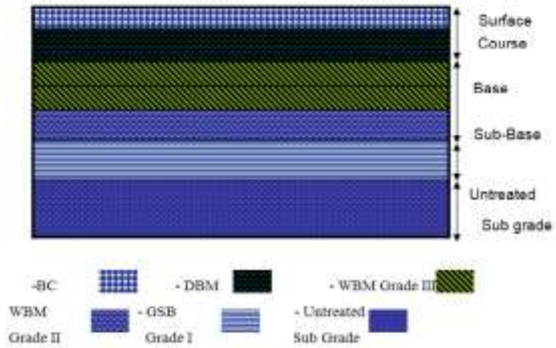

Fig.6 Composition of flexible pavement on untreated clay sub grade

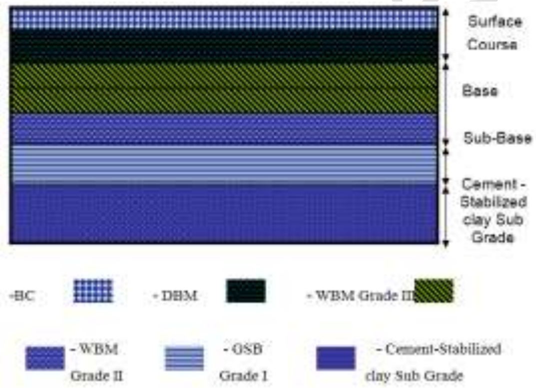

Fig.7 Composition of flexible pavement on Cement-Stabilized clay sub grade

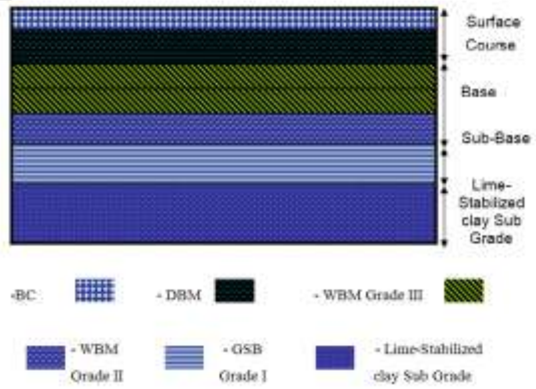

Fig.8 Composition of flexible pavement on Lime-Stabilized clay sub grade

CONCLUSION

The following conclusions can be drawn from the study carried out in this investigation. Based on IRC and AASHTO methods of flexible pavement design, the pavement thickness for untreated, lime-stabilized and cement-stabilized clay sub-grades are obtained and presented in the following table.

S.No	Type of sub-grade	Pavement thickness (mm)	
		IRC METHOD	AASHTO METHOD
1	Un-treated clay sub-grade	780	730
2	Lime- stabilized clay sub-grade(8% lime)	620	600
3	Cement-stabilized clay sub-grade (2%)	680	510

It can be observed that the lime-stabilized clay sub-grade has resulted in less overall pavement thickness followed by cement-stabilized clay sub-grade in comparison with untreated clay sub-grade. Economic analysis is carried out for untreated, lime-stabilized and cement-stabilized expansive soil sub-grades as per Standard Schedule of Rates (SSR), Government of Andhra Pradesh and the results are presented in the following table.

S.No	Type of sub-grade	Cost(Rs)	
		IRC METHOD	AASHTO METHOD
1	Un-treated clay sub-grade	9822225	9467025
2	Lime- stabilized clay sub-grade(8% lime)	9347625	8836800
3	Cement-stabilized clay sub-grade (2%)	8395000	8440875

It is observed that maximum savings are obtained for the pavement constructed on lime-stabilized clay sub-grade followed by the pavement constructed on cement-stabilized clay sub-grade.

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