



REHABILITATION OF SUBGRADE BY USING FLY ASH, COREX AND BLAST FURNACE SLAG

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Abstract: Minimizing the cost of stabilization and improving the swell-shrink behavior & strength of expansive soils are major concerns to geotechnical engineers dealing with construction project over problematic soils. Expansive soil has tremendous strength but it become soft when came into contact with water, it expands during wet condition and shrinks in dry condition because of its mineralogical composition. The stability of structure is majorly influenced by expansive soils. Structures failures due to swell-shrink behavior of expansive soil are reported by many countries. This project is to improve the behavior of such soil by chemical stabilization using Fly Ash and Corex slag and Blast Furnace Slag - industrial waste used to mitigate the problems associated with expansive soil, as well as to solve the disposal problem caused by this waste which is a big environmental issue now a days, considering sustainable approach.

The primary goal of this project is to examine the feasibility of Fly Ash and Corex Slag as a soil stabilizer to improve strength and reduce swell-shrink behavior at all set of possible combination. The results showed better improvement in swell-shrink behavior, unconfined compressive strength, Tri axial (UU Test) and soaked California bearing ratio when combined with Fly Ash – Corex Slag. The results revealed that Fly Ash in combination with Corex slag could be used as a pozzolanic material in soil stabilization to reach the target strength for structures with improved swell- shrink behavior.

Index Terms - Fly Ash, Corex Slag, soil stabilizer, soaked California bearing ratio

I. INTRODUCTION

The quality of roads dictate the economy of a country and hence the quality of our lives. In India, road transport handles more than 60% of the freight and more than 80% of the passenger traffic. Roads are vital for the transport of goods and passengers. Village roads are critical for the basic minimum connectivity for the up liftment of the social and economic condition of the rural people. Such roads provide access to employment, means of transporting agricultural produce and access to health care and social services. Realizing the need for good road infrastructure, the Indian government has embarked on a vigorous road building effort – and investing 1,20,000 crore per annum. In the next five years, \$60 billion

will be invested to build 35,000 km of roads. The roads that are being built now will be ready for maintenance and rehabilitation in the next five to ten years.

Some lessons can be learnt from the US highway system, which is a mature system, and most of the work in the recent past and at present is on maintenance and rehabilitation, rather than on new construction. Because of soaring material costs and budget shortfalls, there is a huge backlog in maintenance and rehabilitation of pavements, leading to the issue of sustainability of the maintenance of road assets that have been created by huge investments. It should be noted that in addition to the ongoing new construction, in the next five years, a significant amount of work will also be needed for the maintenance and rehabilitation of the new pavements. The combined work will need (in addition to money) a massive amount of materials and energy.

The performance of subgrade stabilization with cement, lime or lime/fly ash are extensively studied. However, the use of recycled materials for subgrade stabilization is yet to be properly studied. If proper mix designs and construction specifications for subgrade stabilization with recycled materials are available, those materials can be used for pavement construction. Recycled materials not only provide cheaper alternatives for subgrade stabilization, they also alleviate landfill problems.

Most of the previous studies were related to subgrade modification with recycled materials, limited to quantify immediate benefit through construction facilitation. However, there is a need to identify the long-term benefits and/or associated risks to use recycled material for subgrade stabilization. With satisfactory long-term benefits, subgrade stabilization can be potentially used for optimizing pavement designs that will result in cost effective pavement sections. If this study reveals any long-term risks associated with subgrade stabilization, those will be addressed by either remedial actions or by limiting usage of those stabilizing materials.

1.1 Objective

The primary objective of this project is to evaluate the reclaimed material stabilized with fly ash, corex and blast furnace slag at varying proportions by weight for subgrade applications and their influence on the strength in terms of resilient modulus and unconfined compressive strength.

1.2 Material to be used

I. Black Cotton Soil

Black cotton soil is one of major soil deposits of India. They exhibit high rate of swelling and shrinkage when exposed to changes in moisture content and hence have been found to be most troublesome from engineering consideration. The rate of montmorillonite is more in black cotton soil which causes expansiveness and crack occurs in soil without any warning which is dangerous for construction. Black cotton soils are formed by lava basaltic rocks. Hence they are very dark in color. They develop cracks during dry period and swell if got moisture, hence they are self-tilling in nature, that's why they are fertile and can hold water for long time. Black cotton soils are generally clayey, deep and impermeable. These soils expand and become sticky during rainy season and contract during the dry season causing deep cracks into the soil.



Fig -1.1: Dry Black Cotton Soil

Black cotton soil is comparatively poor for construction purpose than any other soils. Some of the basic properties of BC soil sample taken for the study are mentioned in Table No. 1

Sr. No.	Properties	Soil
1.	Liquid limit (%)	59.79
2.	Plastic limit (%)	36.8
3.	Plasticity index (%)	22.19

Table -1: Properties of BC Soil

II. METHODOLOGY

2.1 PHASE I

In first phase we start from location of the proposed project. Whether the trial sections are carried out and what type of ground conditions observed during the execution of project.

This project is located between Ojhar and Sukene , and which is near about 30 km away from the Nashik city. The trial sections are carried out on a road surface of length 200m. The length of the trial sections is about 50 m each and having total four sections of various stabilized materials. During the excavation of the existing pavement we found various types of soil surfaces such as black cotton soils, murum and at some sections gravel type rocks are observed.

In this site surrounding soil are cultivable so due to this we phases problems like seepage, moisture and piping condition from beside land. So to avoid this type of conditions we need to provide some basic treatments such as drainage and side gutters. At the time of excavation, maintaining the proper depth it is challenging work to site engineer and also for the driver of the excavator.

For the construction of these sections various type of stabilized material used with their predefined properties and with exact proportion which is already found out in the laboratory evaluation.

Fig 2.1 Location of Road Site



Fig 2.2 Details of Road Site

3.2 Phase II

The trial section composed of different layers such as subgrade, subbase, base course and wearing surface. For the construction of such layers different types of materials required along with their suitable property and availability.

Following are the sections which shows the different layers of pavement and there composition with stabilized material.

Section No. 1:-

(Width of Pavement = 3.5m and Length of each section = 50m)

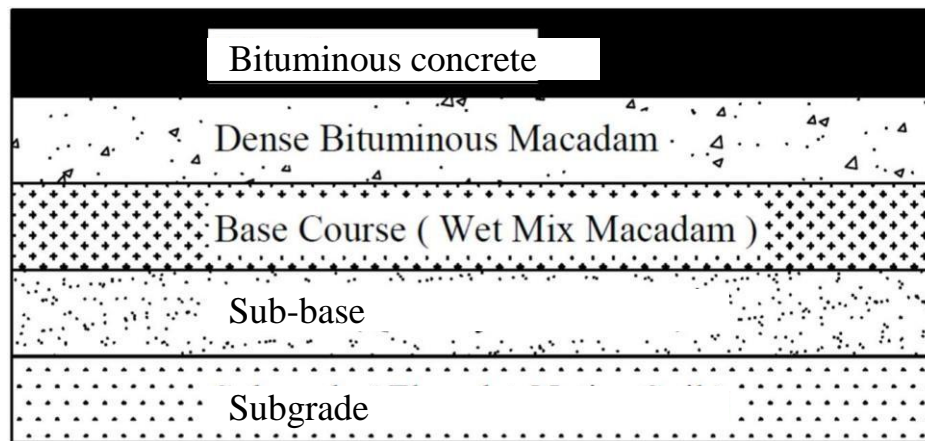


Fig. 2.3 Detail Section of Pavement

The layer of the pavement consists of the different layers with different types of material.

Subgrade: - A subgrade is made up of native soil that has been compacted to withstand the loads above it.

Subbase: - Which consists of commonly used materials such as gravel, crushed stones and subgrade soil.

Base Course: - Base course consists of wet mix macadam. It includes laying, spreading and compacting of clean, crushed, well graded granular material on a prepared and approved granular subbase. The material is well mixed with water and rolled to a dense mass.

Dense Bituminous Macadam: - Is a binder course used in road pavement. It consists of coarse aggregate, Fine aggregate and Binders with varying proportions.

Bituminous concrete: - A mixture of asphalt and graded aggregate widely used as paving material over a prepared base; normally placed, shaped, and compacted while hot, but can be prepared for placement without heat.

Section No. 2:-

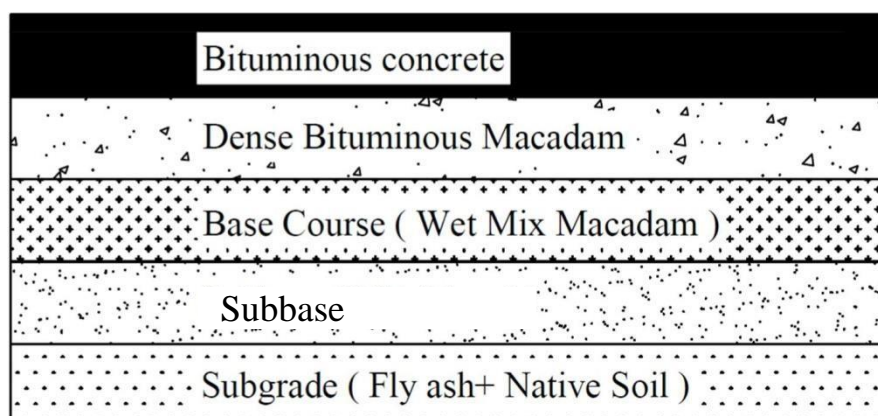


Fig. 2.4 Detail Section of Pavement with fly ash

1. Black Cotton soil: - Expansive soils, popularly known as black cotton soils are amongst the most problematic soils in Civil engineering. The most important characteristic of the soil is, when dry, it shrinks and is hard like stone and has very high bearing capacity. Large cracks are formed at the bulk of the soil.

Properties	Value
Specific Gravity	2.7
Sand content	17.5%
Silt Content	46.5%
Clay Content	36%
Liquid Limit	60.26
Plastic Limit	27.19
Plasticity Index	33.07
Free Swell Index	66.67%
MDD	1.747 g/cc
OMC	20%

Fly Ash: - Fly ash is typically finer than Portland cement and lime. Fly ash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 and 100 micron. Fineness is one of the important properties contributing to the pozzolonic reactivity of flyash. Fly ash purchased from Eklahera, Nashik. Where thermal power plant is situated. 1 bag of fly ash is nearly equals to 1.2 tonne. So we purchased total 350 Bags.

3.3 PHASE III

Field evaluation includes the various works to be carried out for the completion of the trial sections. The works starts from the predefining of the project to the finishing the project. Which includes following works as well as various laboratory tests as follows:

1. Excavation:

The excavation to be carried out on the existing Ground surface with a predefined design depth. Depth of the pavement totally depends upon the traffic density and the subsoil strata condition. The 1000 mm depth is maintained throughout the 200 m length for a Major District Road which are divided into 4



sections of 50m. The excavated material is rack at the side of the road. Which is generally used for stabilizing the embankment of road which is disturbs during excavation. The depth of the pavement decided by using IIT PAVE software and using the IS Codes (i.e. IRC 37)

Fig. 2.5 Excavated depth of the road

3.4 PHASE IV

Evaluation of pavement section using various tests: -

Evaluation means analyze the prepared road surface as well as their layers by using various tests which would either laboratory or field tests.

Laboratory test

Moisture Content Using oven drying method:

Specifications: -

This test is done as per IS: 2720 (Part II) – 1973. The soil specimen should be representative of the soil mass. The quantity of the specimen taken would depend upon the gradation and the maximum size of the particles. For more than 90% of the particles passing through 425 micron IS sieve, the minimum quantity is 25g.

III. RESULTS AND DISCUSSION

4.1 Analysis

Wt. of wet sample = 100 gm

Section No.	Wt. of Empty container (W1)	Wet sample+ Container (W2)	Dry sample+ Container (W3)	Wt. Of Water (W2-W3)	Wt. of solids (W3-W1)	Water Content $\left\{ \frac{W2-W3}{W3-W1} \right\} * 100$ %
1	22	122	103.6	18.4	81.6	22.55
2	22.4	122.4	113.8	8.6	91.4	9.41

These observations taken on both trial sections at mid chainage of each.

A) Dry density using core cutter: -

$$\Delta d = \Delta t / (1+w) \text{ gm/cm}^3 \text{ OR}$$

$$\Delta d = \Delta t / (1+w) \text{ kN/m}^3$$

Where, Δd = dry density in g/cm³,

DELTA d = dry unit weight in g/cm³,

DELTA t = field moist density in g/cm³,

DELTA t = field moist unit weight in g/cm³, w = water content

%/100,

DELTA w = unit weight of water = 9.81 kN/m³

Analysis: -

Water content for section 1 and 2

Water Content (%)	Section-1	Section-2
	22.55	9.41

Dry density for Section 1 and 2

Section No.	Empty Wt. Of Mould (W1)	Wt. of Mould + Sample (W2)	Net Wt. (W2- W1)	Volume	BULK DENSITY (ρ_b) = W/V	Dry Density ($\rho_d = \rho_b / (1 + W)$) g/cm ³
1	932	2966	2034	1021.01	1.99	1.63
2	932	2981	2049	1021.01	2.01	1.83

B) Determination of Plastic limit of the soil: -

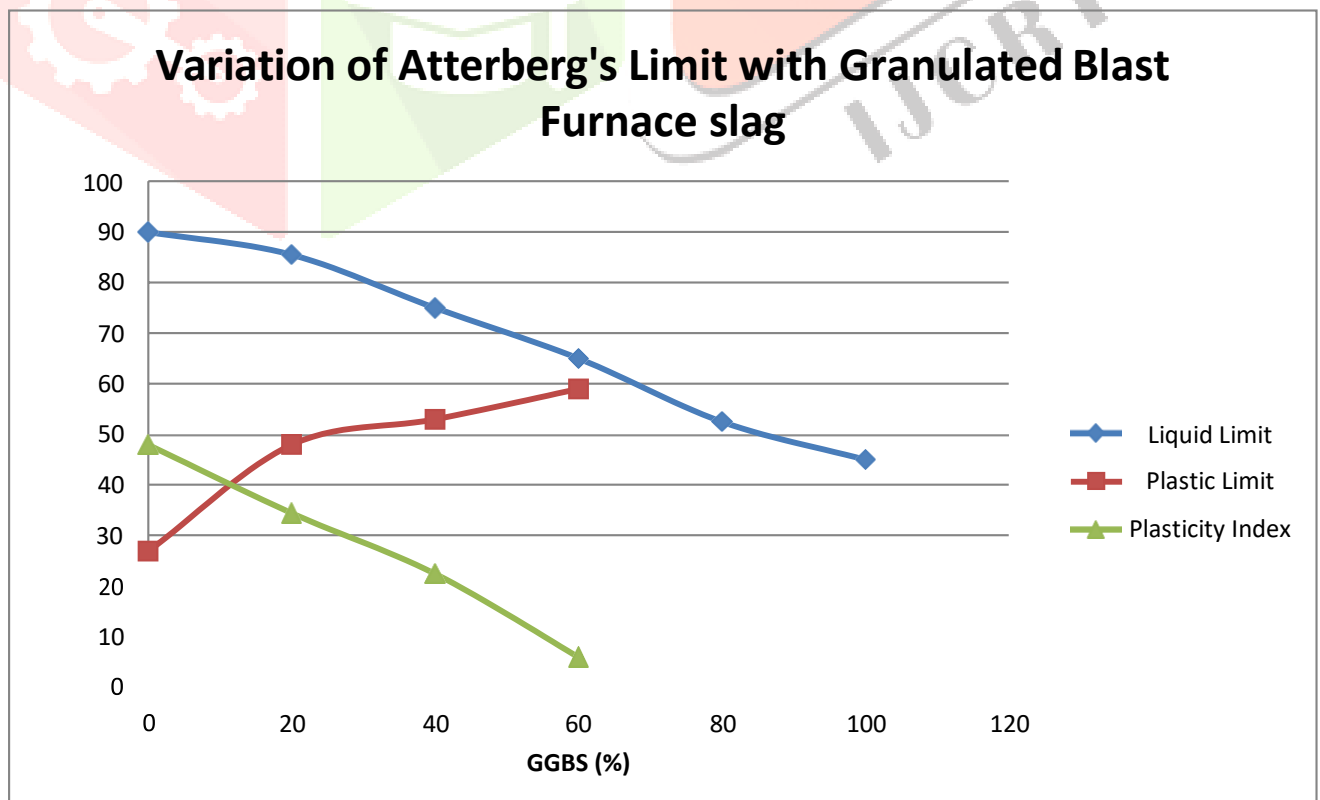


Fig. 4.1 Variation of Atterberg's limits with Blast furnace slag

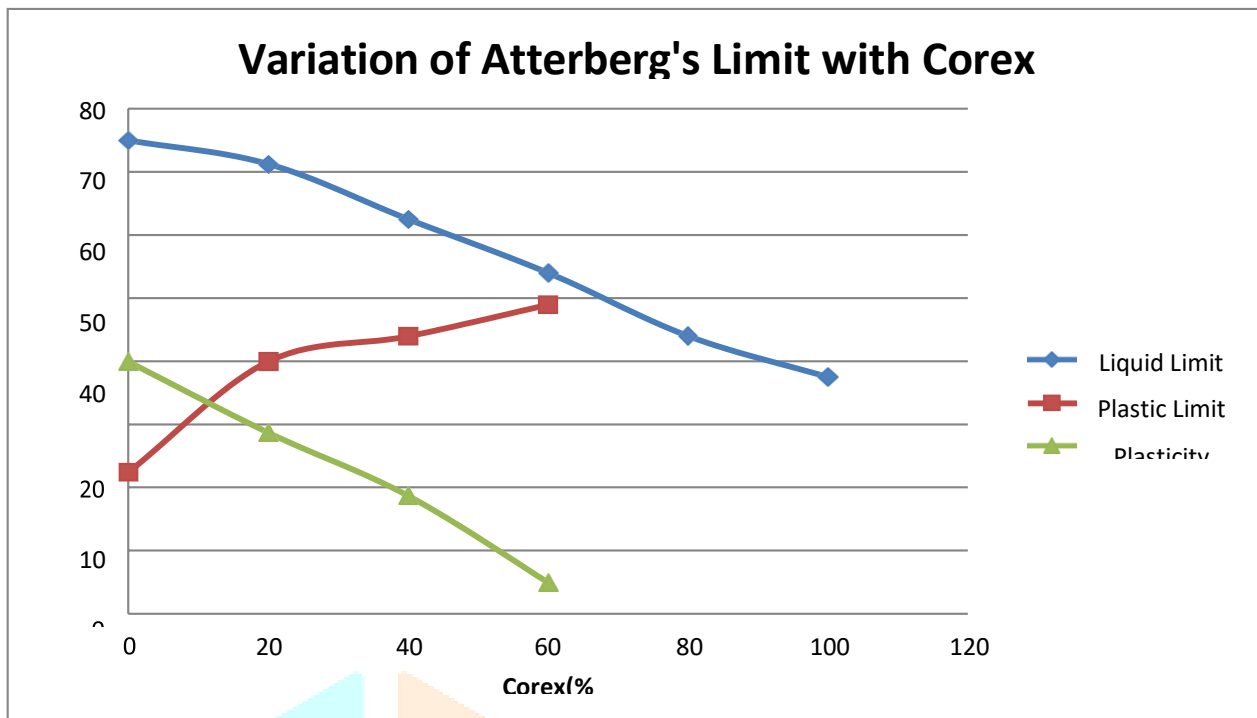


Fig. 3.2 Variation of Atterberg's limits with Corex

IV.

Conclusion

- a. Liquid limit and Plasticity index decreases with increase in corex percentage and Granulated Blast furnace slag percentage content. Plastic limit increases as corex percentage and Granulated Blast furnace slag percentage increases. Non plastic behavior was observed for Corex and Granulated blast furnace slag content of 80% and 100%.
- b. At 80% Fly Ash we get the highest UCS value. Black cotton soil is cohesive in nature and Fly Ash is non cohesive, so at 100% Fly Ash strength is lower. For soil with 0% FA UCS is lower.
- c. Resilient Modulus of Black cotton soil- fly ash mixes increases with increases in fly ash content upto 40% and decreases thereafter for 28 days. Resilient Modulus of Black cotton soil – Corex mixes increases with increase in corex content upto 50% and decreases thereafter for 28 days. Resilient Modulus of black cotton soil- Blast furnace slag mixes- increases with increases in slag content upto 65% and decreases thereafter for 28 days.

Black cotton soil is highly plastic, it has more shrinkage cracks therefore black cotton soil is stabilized with Corex, blast furnace slag and fly ash.

Advantages of black cotton soil stabilization:

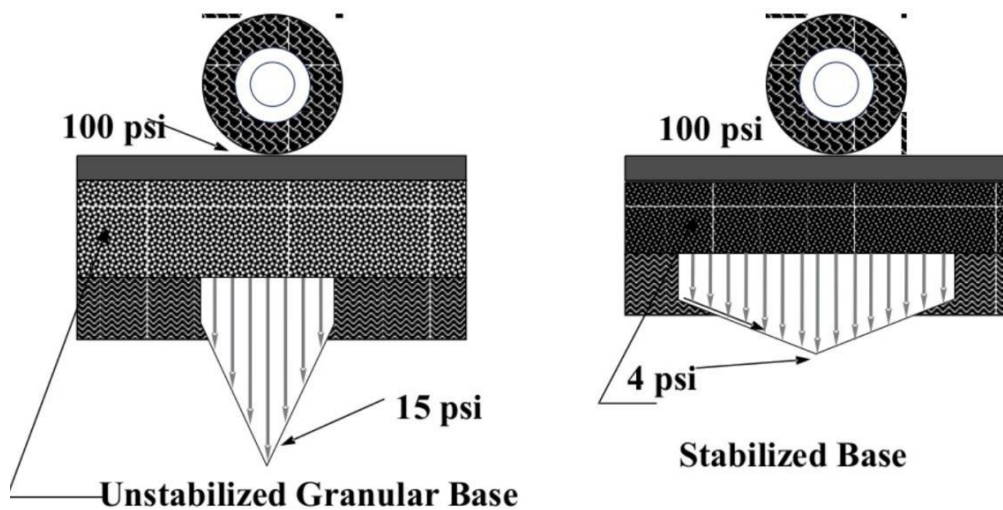
Reduction in soil plasticity.

Improved compactibility.

Reduction of soil capacity to swell and shrink.

Improve strength and stability after compaction.

Spread Loads:



V. Fig 4.1 Spread Loads

On unstabilize granular subgrade the stress intensity is quite high below the wheel surface. Where as on stabilized subgrade, wheel load is distributed on a larger area which results in lower stress below the wheel and in the subgrade level.

Eliminates Rutting below surface:

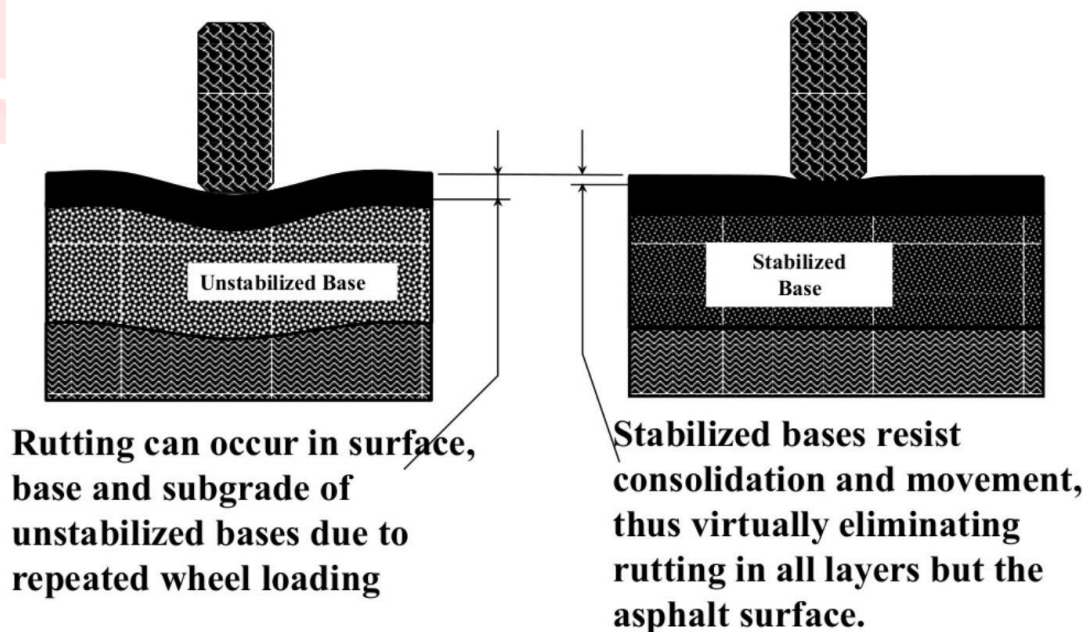


Fig 4.2 Rutting below surface for stabilized and unstabilized base

If the stabilized subgrade is available then rutting will occur only at top surface. Which is easily maintained and has low maintenance cost.

For unstabilized subgrade, rutting will occur in all layers of the subgrade. Which is high maintenance cost and proves expensive

Reduced Moisture Susceptibility:

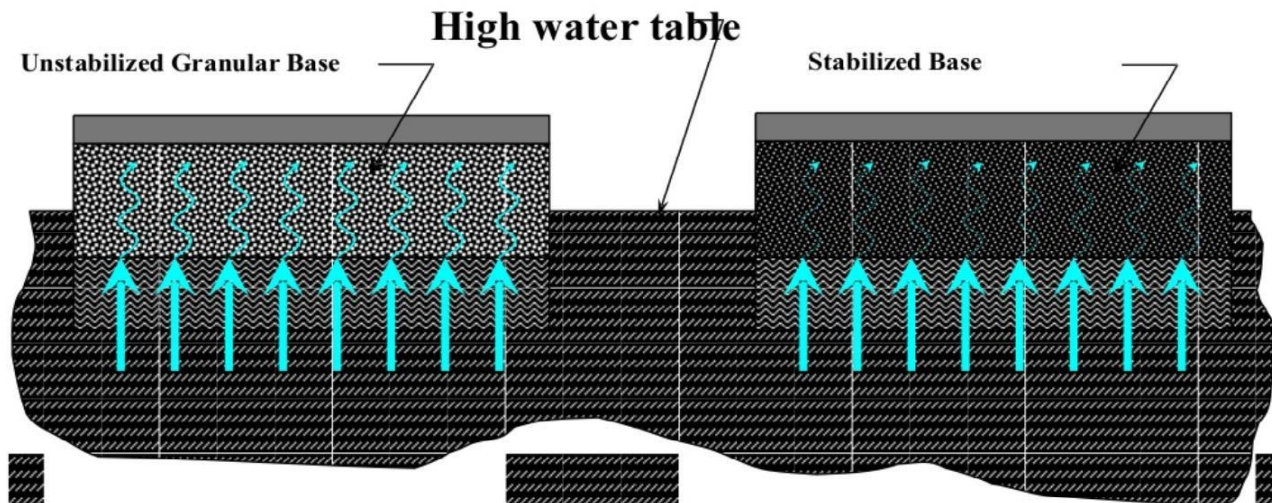


Fig 4.3 Moisture susceptibility on stabilized and unstabilized base

In Unstabilized Granular base, the permeability is high and water can easily seep into the pavement. Which may ultimately lead to the failure of pavement.

In Stabilized Granular base, the permeability is reduced and there is no seepage of water into the pavement and thus increases the life of pavement.

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