CHAPTER 1
INTRODUCTION

1.1 GENERAL

For rapid development of any country, accessibility and interconnectivity of different places through well connected transportation network with reasonable serviceability is essential. Road transportation is the most adaptable mode of transport under varied conditions of topography and hence top priority is given by the governments to improve road transportation facilities throughout the world through allocation of huge capital investments.

In India Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched on 25th December, 2000, as a fully funded centrally sponsored scheme to provide all weather road connectivity in rural areas of the country. The program envisages connecting all habitations with a population of 500 persons and above in the plain areas and 250 persons and above in hill sites, tribal and desert areas. This involves construction of about 3.71 lakh km of road for new connectivity and 3.68 lakh km roads under upgradation. In the four-year business plan for rural connectivity (2005-2009) it is decided to connect 66,802 habitations with all weather roads by constructing 1,46,185 kilometers of the new rural roads network and upgradation of 1,94,132 kilometers of the existing rural roads.
network with a huge investment of Rs. 48,000 crores over four years. Quality of roads is the main concern in this program.

In the process of development of a country, governments continuously improve road networks by connecting different places in the shortest path. In this process the pavements have to pass through different subgrade soils. In India about 40% of total land area is covered by clayey soils. So inevitably the roads have to pass through these weak clayey subgrade soils. These soils swell and shrink with moisture fluctuations and pavements constructed on these weak subgrades suffer cracks and settlement of sub base in to subgrade. As it is unavoidable to lay pavement on these soils, there is necessity for a design methodology which ensures safety of pavements against these weak subgrades.

The construction of pavements over clay subgrades is expensive, as they require large pavement thickness due to lower CBR values in wet condition. Pavement failures are often noticeable in pavements constructed over clay soil despite building pavements with large thickness. Swelling of subgrade is seen in low traffic roads whereas heavy traffic roads are affected by excessive settlements or shear failures in the edge regions. The pavements give poor service when there is volume instability of the subgrade and they also require periodic maintenance after every rainy season.

Pavement constructions are classified as flexible pavements and rigid pavements. Generally flexible pavements are preferred to rigid pavements due to their less initial cost, smooth riding surface and easy maintenance.

1.2 FAILURES IN FLEXIBLE PAVEMENTS OVER CLAY SUBGRADES

Premature failures are common in flexible pavements over clay subgrade. In rainy seasons, the subgrade soil gets softened and intrusion of subsoil into sub base will take place resulting in failure of the flexible pavement.

The types of failures in clayey subgrades are:

**Large pavement thickness**

In wet condition expansive soils swell more and strength will decrease leading to large pavement thickness. Hence the construction cost will increase.
Instability of Pavement
Due to moisture variation in different seasons, expansive subgrade is subjected to alternate swelling and shrinkage which leads to disturbance in different layers of pavement. This will cause instability in the pavement.

Shear failure in Shoulder Region
The shear failure of single lane roads in expansive soil subgrades is common due overtaking of vehicles in rainy season (Patel and Qureshi, 1979).

Undulated Pavement Surface
The soil gets softened in the edge portions in rainy season. The deformation will be more in edge portions due to wheel tracking on this softened edge portion leading to undulations in pavement surface.

Deterioration of Pavement
Sub soil intrusion into softened subgrade takes place in rainy season leading to intermixing of structural layers of pavement with subgrade. This will cause progressive reduction in the thickness of pavement over a period of time and failure under design traffic.

Stripping of Bitumen
In rainy season, moisture rise from subgrade to surface leads to stripping of bitumen. This stripping of bitumen causes raveling of aggregate.

Volume Instability
There will be volume instability, sub soil intrusion into overlying structural layers of pavements, softening of subgrade soil during rainy season and penetration of sub base course material into softened subgrade.

1.3 EXISTING PRACTICES FOR CLAY SUBGRADE IMPROVEMENT
Soils that are highly susceptible to volume and strength changes can accelerate the deterioration of the pavement structure in the form of increased cracking and decreased ride quality when combined with truck traffic. The subgrade soil can be treated with various materials to improve the strength and stiffness characteristics of the soil. Soil stabilization can be done either using mechanical methods like adding more gravel, blending and using geotextile or by adding admixtures like port land cement, lime, fly ash, bituminous etc or by using water proofers.
Blending gravel and, more recently, recycled pavement material with poorer quality soils can also provide a working platform. The gravel acts as filler, creating a dryer condition and decreasing the influence of plasticity. However, if saturation conditions return, the gravel blend can take on the same poorer support characteristics of the subgrade. Geotextiles and geogrids reduce the extent of stress on the subgrade and prevent base aggregate from penetrating into the subgrade, thus reducing the thickness of aggregate required to stabilize the subgrade.

Stabilization with admixtures, such as lime, cement, and asphalt, have been mixed with subgrade soils used for controlling the swelling and frost heave of soils and improving the strength characteristics of unsuitable soils. For admixture stabilization or modification of cohesive soils, hydrated lime is the most widely used. Lime is applicable in clay soils (CH and CL type of soils) and in granular soils containing clay binder (GC and SC type of soils), while port land cement is more commonly used in non-plastic soils. Lime reduces the plasticity index (PI) and renders a clay soil less sensitive to moisture changes. The use of lime should be considered whenever the PI of the soil is greater than 12. In case of stabilization with bitumen the mixing is the problem. When Pozzolanic and slag are added they act as fillers and increase density but they are slower than cement.

Water proofers like Asphalt geomembrane may be used to reduce soil moisture. But long-term migration problem exists.

1.4 NEED FOR THE STUDY

In India about 40% of land area is covered by clay soils and about 30% of clay soils are expansive nature. Most of the pavements constructed on clay soil sub grade results large ruts, cracking of pavement surface and pot holes. Due to this the pavements on clay soil subgrade do not serve for long and offer poor riding surface. So, efforts are being made to improve subgrade strength by stabilizing the 1m thick top soil by lime stabilization or soil replacement or chemical stabilization or by placing geosynthetics.
In the last two decades geosynthetics have attracted the attention of researchers. The majority of studies reviewed, indicate appreciable improvement in pavement performance can be achieved by proper placement of geosynthetic as a separator between base and subgrade material, which prevents the mixing of subgrade soil and granular base material and the resulting deterioration of base course. In the recent development, researchers are concentrating to improve performance of pavements by laying geotextiles and geogrids over the compacted subgrade before spreading base course of aggregate, thus serving the purpose of separation and also reinforcing the pavement by sharing the load through its membrane action.

Reinforcement increases the bearing capacity of the subgrade, stiffens the base layer there by reducing normal stress and changing the magnitude and orientation of shear stress on the subgrade in the loaded area, restricts lateral movement of the base course material and the subgrade soil, and can provide tensioned membrane support when deep rutting occurs (Giroud et al. 1985).

The higher the stiffness of the geotextile with assured interface friction, the better will be the triggering up of membrane action at an early stage of deformation. The significant difference between geogrid and geotextile is, in geogrids due to their large apertures, they may interlock with the base course aggregate. As a result of interlocking, the mechanisms of unpaved structure reinforcement are different for geotextiles and geogrids. Geogrids can improve the performance of the subgrade soil through four mechanisms: prevention of local shearing of the subgrade, improvement of load distribution through the base course, reduction or orientation of shear stresses on the subgrade and tensioned membrane effect.

The existing methods of soil stabilization are soil replacement (Snethen, 1979), use of moisture barriers to check entry of moisture into subgrade soil (Snethen, 1979; Steinberg, 1992), use of cohesive non-swelling soil cushions to suppress swelling of the subgrade soil (Katti, 1979) and pre-wetting (Subba Rao et al., 1980).

Soil replacement is costly and feasible when a suitable refill is available nearby. The CNS soils cannot totally control subsoil intrusion that too in long period the results are not good. In case of pre-wetting it requires longer period and uniform mixing is also a problem.
None of the design techniques are aimed at reducing design pavement thickness. Hence there is need for development of design methodology aimed at reducing required pavement thickness and improved performance.

1.5 AIM AND OBJECTIVES OF THE STUDY

The present work is aimed at formulating design methodologies for reinforced flexible pavement design over expansive and non expansive clay subgrades. It is also intended to evaluate the performance of test tracks laid based on the developed design methodologies. To achieve the aim, the work has been planned with the following objectives.

- To critically study the available reinforced flexible design methodologies of reinforced flexible pavements.

- To understand the concepts of membrane action of geotextile fabric reinforcement and reinforced soil mattress over soft subgrade.

- To develop a design methodology for reinforced flexible pavement over expansive clay sub grade ensuring safety against swell, shear failure and settlement failure risks.

- To develop reinforced flexible design methodology over non swelling clay subgrade with the objectives of reduced pavement thickness and safety against shear and settlement failures.

- To lay unreinforced and reinforced test tracks over non expansive and expansive clay subgrades under the study.

- To evaluate the performance of laid test tracks under traffic and varied moisture conditions.