Study of improvement in properties of subgrade by using Geo-Textiles and Lime

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Abstract: The best connectivity to any part of the country is first to develop infrastructure of the country. The use of geo-textiles in flexible pavements has been a well-accepted practice over the past thirty years. In most recent years, the base course of flexible pavement is reinforced by geo-textiles to improve performance and to reduce the thickness of base course. There are two major types of pavements: flexible and rigid. In this we are discussing about the flexible pavements. The performance of some flexible pavements in some climatic condition has been proved disappointing because a transverse crack has been developed within a few years of construction. Other forms of flexible pavements distress include alligator or map cracks, ruts and reflective cracking. The additional benefit in the construction of flexible pavement by using geo-textile is that they are very stiff.

This paper examines about usage of woven geo-textiles in flexible pavements. The locally available soil is used for the tests. Different test are performed for soil along with geo-textile. In CBR test geo-textile is installed at different depths in soil such as 3, 6 & 9 centimetres in the mould. From this study, layer of woven geo-textile introduced at the centre shows the better performance than those of other layers at different depths. Review of the most papers concluded by using Geo- textiles in the flexible pavement can rise the service life of the pavement than the previous pavements. Geo-textiles of both natural and synthetic are helpful in improving the geo-technical properties of soil. These fabrics are used for erosion control, filtration, for vegetation support etc. Geo-textile is eco-friendly and can be used in road works cost effectively.

Keywords: flexible pavements, Geo-textiles, Sieve analysis, Liquid limit, Plastic limit, Standard proctor test, California bearing ratio (CBR)

INTRODUCTION
In the past 20 years the geo-textiles growth in the market has risen. In Geo-textiles Geo means Earth and textile means fabric. Polypropylene, polyethylene, polyester are the petroleum products which used in the production of Geo-textiles. Fiberglass is also an alternate source in which geotextile can be made. Depending on the manufacturing they are classified into two types. The flexibility of geotextile is most useful for the filtration purpose and soil, rock and waste material can be reinforced by the geotextiles. These textiles consists of synthetic fibres such as cotton, wool or silk. Flexibility and porous nature can be obtained by the usage of standard weaving machinery. Subsurface drainage and erosion control applications as well as for road stabilization for wet moisture sensitive soils are given by Non-woven geotextiles. Woven geotextile are made from weaving monofilament, multifilament, or silt film yarns. Silt film yarns further subdivided into flat tapes and fibrillated yarns. There are two steps for making woven geotextiles. First manufacturing of filaments or slitting the thin film to create yarns. In second weaving the geotextiles to form yarns.as the geo-textile is made from different process the range of properties is very high. Geotextile fabrics come in three basic forms namely woven, needle punched, heat bonded. There are different types of geo-synthetics namely geo- membranes, geo-nets, geo-composites, geo-mat, geo-cell, bio-mat and bio-net. Some of the natural forms of geotextiles are jute, flax or coir, coconut matting, cotton, hemp, straw. The different types of composite/synthetic materials of geotextiles are Kevlar, polyester, polypropylene, jute composite.

1. BACKGROUND
Inclusions of different sort of mixes with soil is introduced in the past. They are initially used in road construction in roman roads. These initial efforts were made to usage of natural fibres to mix with soil to improve quality of road. Pharaohs are the days where textile products are first used in the roads. U.S first incorporated geo textiles beneath roads in the 1960’s. In early 1970’s, 3 million square yards of geo textiles were used in infrastructure projects. By the 2000’s more than 300 million square yards were used beneath the roads through the world. Most state department of transportation (DOT) have standard specifications for their use in roads.

Growth rate in geo textile scales during the 1980’s have averaged about 20 percent each year. Both woven and non-woven geo textile fabrics are made from poly propylene, polyester, nylon and polyethylene. These fabrics have varying material properties including stiffness, strength and creep characteristics. More recently polyethylene and polypropylene geo-grids have been introduced in Canada and then in U.S.

2. NEED OF STUDY
The economic development for a country can be judged by its road transport facilities available. When there are unpaved roads set on soft sub-grade it can go through large malformation, while periodic care of the rural road is finite due to cost effect. In these situations, Geo-textiles can be utilized to improve not only performance, but it will reduce the repair cost as well as it decreases the
thickness of the pavement.

Now-a-days geo-textiles are widely used in highway engineering to solve a variety of problems drainage, separation, and reinforcement of pavement structure. The geo-textile reinforcement is a superior solution for the construction on weak sub-grade soils. They have long life too. These materials are cheap, easy laying in field and biodegradable. The use of natural geo-textiles has not gained popularity in India.

A primary function of a geotextiles used in the road way construction is the separation between the dissimilar construction materials. Using non-woven and high permittivity woven geotextiles offers a filtration and drainage function and is a part of separate function. High permittivity geotextiles allows water to pass while filtering out fine subgrade soil particles from penetrating through base course layer. Only high permittivity geotextiles should be used on subgrade soils. Beneath repeated loads, the aggregate layer aim to expanse laterally, after all geotextile placed at intensity of huge lateral strain, the shear stress can be transmitted to tensile stress. If geotextile used is rigid, it results in unyielding road.

All most all geotextiles materials in united-states are derived from either polyester or polypropylene. Polypropylene weighs less compared to water, tough and stable. Staple fibres are used for assembling woven and non-woven geotextiles. Polyester is heavy than water, has excellent strength, creep properties. Geotextiles are pervious between the laying course and the permeable sub-base. They are informally referred as filter fabrics. The diameter of pores within geotextiles can vary from 0.02 to 0.002 inches. In some permeable pavements, a geotextile layer under a base course can distribute the traffic weight over soft subgrade. While the subgrade deform under any load the geo-textile layer is placed and its tensile strength properties will increase.

Geotextiles will increase stability as well as improves enforcement of subgrade soils especially by splitting the aggregates from the subgrade. Geo-grids, Geo textiles can give strength through interlocking between the aggregates and geo-synthetics

3. SCOPE

The scope for this study is finite for usage of geo-textiles in flexible pavement and cost analysis was not done. Data from the literature review is taken as a guide, and is not integrated. It covers include types, functions, test procedure for flexible pavement are included. This study does not cover the other materials of geo- synthetics such as geo-grids, geo-nets, geo-membranes etc.

4. OBJECTIVE

In India, the main problem for the roads is because of their service life, due to fact that the load accounted during the design of road is far lower than ground reality. In many places in the world, quality natural materials are unavailable or in shortages. Bringing from far places increase fuel consumption. Due to these reasons engineers are concentrating towards locally available materials. The strength of soil can be increased by using soil stabilization technique such as use of polymeric materials (Geo-synthetics, Geo-textiles and Geo-grids etc.). Geo textiles are first examined for reinforcement in paved roads in 1980’s.

In India, the use of geo textiles is gaining popularity particularly for road repairs and road rehabilitation. Geo textiles are used commonly at the sub grade soil level primarily for filtration and reinforcement functions. Apart from this geo textiles can be incorporated in the pavement overlay of roads and also as a surface overlay.

Occasionally there is need to construct a road on poor quality soil. The roads constructed on soil of black cotton develop wavy form on the surface of road due to ruin strength of the sub grade during monsoon season. The main problem facing by the highway engineers is to laying a road on the black cotton soil. In dry state it shrinks. During rains, it swells as well as loses strength and poses serious problems. This is the reason for road engineers do not construct on black cotton soil particularly in Madhya Pradesh. They are many methods for ground improvement such as cement stabilization, chemical stabilization etc., but these additives do not mix properly with soil. Geotextiles is used in the construction of pavements and embankments on soft soil.

Selecting geotextile for permanent road or temporary road depends on the survivability criteria. The geo textile can be selected in roadway functions is usually administered by some of certain construction stresses. The selected geo textile must absorb some amount of subgrade soil.

In this main objective is to quantify the using of geo- textiles in flexible pavements. Different pavement design roads are taken into consideration. The predicted pavement service life of different pavement structures and were taken into consideration and compared with service life of the pavement with geo-textiles.

5. LITERATURE REVIEW

The literature review is in reference to the use of geotextiles in flexible pavement, online databases searched. To achieve the desired goals many previous studies that were same or similar are studied for better understanding and further progress to the project. I have studied different papers which are similar to my research of different countries which are completed.

The results of this search revealed considerable references to published information on the use of geotextiles in pavement construction. However, only limited references are available to published information geotextile usage in flexible pavement road construction and very little is related to usage in airport pavement construction. This published information includes design guidelines, important properties, functions and construction and designers.

KHALID ET AL (2004):

He discussed that the overview of the current geotextile technologies and highlights the functions geo-textile performing in enhancing the performance and extending the service life of paved roads.
CANNELLI (1992)
He showed that a woven geo-textile of high modulus reinforced section performed somewhat better than the control section, where stiff geo-grid and multi layered geo-grid have shown a significant improvement.

KILLEAVEY AND ANDERSON (1989)
Both of them tested 3 sections of different base coarse thickness that were designed to perform same. The geo-textile reinforced thickness of base can lessen from 450 to 350 mm.

KHALID (2004)
He discussed that the overview of the current geo-textile technologies and highlights the functions geo-textiles perform in enhancing the performance and extending the service of paved roads.

CLEVELAND ET AL (2002)
He observed that the main intension of the research was to check geo-textiles placed under or hot mix asphalt (HMA) overlay to lessen the severity or to lag the presence of reflection cracks. Bashery (2009) assist pavement design engineers in the selection of an appropriate sub-grade enhancement geo-textile (SEG) formerly called sub-grade enhancement fabric (SEF). Bushey (1976) concluded that all reflection cracks are greater than ¼ inch wide in hot mix asphalt overlays.

HICKS ET AL (1986)
He reports that a base contamination of about 10 percent subgrade soil fines can destroy structural strength of base layer. The problem of contamination can be solved by placing geo-textile at sub-grade level. Further by placing geo-textile as a separator between base course and sub-grade soil permits to drain off quickly through and along the plane of fabric. Due to multi-functions like separation, filtration, reinforcement and drainage, geo-textiles can be used in un-paved roads.

AL-QADI (1994)
The main function of the geo-textile is recognised as separation in the pavements, especially when they are used to enhance the road with low bearing capacity subgrade.

CHRISTOPHER AND HOLTZ (1991)
When dynamic wheel loading is applied, high pore-water pressure is induced. This will cause the hydraulic gradient between base layer and subgrade soil. Therefore after placing a proper geo-textile layer at the subgrade base interface can reduce the upward plastic flow of subgrade soil because the layer can help to dissipate the excess pore water pressure.

VAN SANTVOORT (1994)
When geo-textile is used as a separator there are some requirements to be followed.

NISHIDA AND NISHIGATA (1994)
They found the boundary between the separation and reinforcement functions.

LE (1982)
He describes the various types of geo-textiles used in the construction of different types of roads.

TSAI ET AL (1993)
He performed a field test and compared ability of different types and weights of geo-textiles to stabilize the soft subgrade during construction and to investigate their long time performances over the pavement system.

BLACK AND HOLTZ (1999)
They reported a long term evaluation result where after five years of geo-textile installation. Subgrade soil at this test site consolidated since the geo-textile has installed. They also stated that long term performance of geo-textile may not be critical since the increase in strength of sub-grade and compressibility reduction due to consolidation.

AL-OADI ET AL (1994)
He performed different tests on pavements of both with and without geotextiles.

ELVIDGE & RAYMOND (1999)
They carried out field tests and laboratory tests are carried out for unpaved roads.

As we know, the Geo-synthetic institute (GSI) and Bombay Textile Research Association (BTRA) had held a summit discussing about the world -wide demand of Geo synthetics and is projected to increase about 9% annually to 6 billion in 2015. The total production of Geo synthetics in India is in the range of 1053 million with imports about 100 million. Global Geo textiles market to surpass U.S $8 billion by 2020.

7.1 GEO-SYNTHETICS
The definition of geo-synthetics is at least one of the components is made from polymeric material inclusion of soils or other geotechnical engineering materials. The main function of geo-synthetics in the pavement are separation, drainage, filtration and reinforcement. Some of the main categories of geo-synthetics are geo-textiles, geo-grids, geo-nets, geo-membranes, geo-composites, geo-foam, and geo-cells. The main function of geo-synthetics is to have better performance and save money. However in this review we will concentrate on the function of geo-textile products.

7.2 GEO-TEXTILES
Geo-textiles are first used in the days of second intermediate period (1802-1550 BC) of Egypt. Even though they were strive for unsteady soils. They finally found that fibres will upgrade the road condition especially for unstable type soils.

Geo-textiles are main largest group of geo-synthetics. The synthetic fibres are main proportions intruded for these textiles. These synthetic fibres are usually built into flexible, permeable fabrics.

The first use of geo-textile used in America in the late 1920’s, in the state of south California used a first geo-textile in a road of
poor quality soil. After several years also the geo-textile was still useful status. Synthetic fibres are easily accessible to buy in the 1960’s, textiles were mostly used in construction of roads. During the past twenty years, geo-textiles are been good for the improvement of performance in paved and unpaved roads. Both woven and non-woven geo-textiles operated for the separation/stabilization of primary highway, low volume roads, paved roads, un- paved roads, parking lots and industrial yards.

Modern geo-textiles are mainly constituents of polypropylenes (85%), polyesters (12%), polyethylene (2%), and polyimides (1%) which do not decompose under any biological and chemical processes. This will helps in construction and maintenance of roads. The making of geo-textiles can be outlined three types as follows:

(i) The first step is to produce polymers from polymeric materials.
(ii) Then secondly polymers are made into fibres.
(iii) The resulting fibre filaments are then seasoned (hardened) by one of the three methods wet, dry, melting. The principle fibre used in the construction of geo-textiles are mono filament, multi filament, slit-film mono filament, slit-film multi filament, staple yarn.

Finally the fibres formed into geo-textiles. Then

- Woven geo-textiles are fabricated using classical weaving methods.
- Non-woven geo-textiles are produced by placing and orienting the fabrics on a conveyor belt and bind with needle punching. The needle punching process consists of pushing many needles.

Normally woven geo-textiles doesn’t penetrate water to flow freely as non-woven geo-textiles. This helps in filtration, as well as fabric doesn’t grant soil particles to move willingly, ultimately the roads built with woven geo textiles erode less and life time will be high.

Non-woven geo-textiles allows water flow forwards through the fabric, which is peculiarly important when geo-textiles used in drainage functions.

7.3 COMPOSITE GEO-TEXTILES
The materials which formed by combination of two or more of the fabrication techniques. The most common composite geo-textile is non-woven mat that has been bonded by resin bonding to one or both sides.

7.4 GEO-TEXTILE DURABILITY
Polymer exposed to sunshine they can deteriorate their physical properties. The rate of degradation can be reduced up to some extent addition of carbon black. Polymeric materials can convert into brittle at very cold conditions. Chemicals in ground water will react with polymers. While low pH can be impact on polyamides and high pH can be impact on polyesters. All these factors should be considered in selecting geo-textile materials. Periodical maintenance should be done.

7.5 GEO-TEXTILE FUNCTIONS
Geo-textiles have different functions in pavements such as separation, filtration, drainage and reinforcement. However, geo-textiles over three decades successful use as stabilizers for very soft and wet subgrade.

SEPARATION
Inserting a flexible porous geo-textile will prevent mixing between two layers of soil.

DRAINAGE
Geo-synthetic will allow the passage of water either downward through the geo-synthetic into the sub-soil or laterally within the synthetic material.

REINFORCEMENT
The geo-textile can toughen or increase the apparent soil support.

Filtration
The fabric of textile allows water to move through the soil perhaps restricting the action of soil particles. The capacity for flow water normal to plane of geo-textile is referred to as permittivity. The performance and service life can be improved by incorporating geo-textile in pavement design. All roadways derive their strength and stability by sub-grade. The pavements lose their designed thickness over a period of time due to intrusion of soft sub-grade material into aggregate base and penetration of base material into subgrade. When thickness is reduced it leads to progressive failure mechanism resulting in need for road maintenance.

6.7 APPLICATIONS OF GEO-TEXTILES

6.7.1 MOISTURE BARRIER
Both woven and non-woven geo-textiles can reduce the moisture when in bituminous, rubber bitumen, and polymeric mixtures. The moisture barrier is the main function plays in the use of geo-textiles in paving overlays. It reduces the surface water entering in the base and sub-grade. Ultimately improves the performance of the pavement system.

EROSION CONTROL
In this geo-textile safeguards soil surfaces from the tractive forces of wind and rainfall. Geo-textiles also one of the alternative protection against erosion on newly laid slopes. The erosion control function can be act as special case such as combination of the filtration and separation functions.

SEDIMENT CONTROL
Geo-textile can serve as sediment control. A silt fence which is composed of a geotextile acts as a vertical barrier. The silt fence reduces the velocity of water allowing the sediment out of suspension.
7.7 MEMBRANE ACTION OF GEO-TEXTILES

Geo-textile reinforcement not only cause load distribution but also it supports a load through a mechanism called “Tensioned membrane effect”. The effect consists in the decreasing the load induced in the sub-grade soil and transfer the load to the lateral zones that is away from the wheels. Due to traffic loads the geo-synthetic is deformed. Under the wheels, due to rutting, the geo-synthetic has concave shape.

In literature review we refer to the previous studies done by different engineers. We collect some data about the project experimentation and some suggestions. Generally data is of two type’s i.e.

- Primary data,
- Secondary data.

Primary data is usually concerned about the collection of data through experience in the site. Secondary data relates to the collection of data through journals, books, internet, newspapers, publications etc.

After all this our methodology of experimentation starts by collecting the data and doing the experimentation. In the experimentation we will study about the different tests to be conducted on the soil.

In experimentation the following tests are conducted:

a) Sieve analysis
b) Casagrande’s apparatus for Liquid limit
c) Determination of Plastic limit
d) Standard proctor test
e) California bearing ratio (CBR)

Generally after the experimentation we go for the analysis part. Analysis can be done through graphs. After that the using of the CBR value we design the thickness of the pavement using code book (IS 37-2012).

REFERENCES