Application of Geo-Textiles in Road Construction

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Abstract

Geotextiles play a very important and crucial role in the civil engineering works. Geotextiles are permeable textile structures made of polymeric materials and are used mainly in civil engineering applications in conjunction with soil, rock and water, performing various functions such as separation, filtration, drainage and reinforcement. They come in three basic forms: woven, non-woven, or knitted. They are the largest group of geosynthetics in terms of volume. They are used in geotechnical engineering, heavy construction, building and roadway construction, hydrogeology and environmental engineering, etc. Geotextiles are used with foundations, soil, rock, earth or any other related material as an integral part of any project, structure, or system. The possible applications of geotextiles in civil engineering field have been successfully developed and are beneficial in terms of economics, durability and performance. They are used in earth dam, roadway, highway, rail road, and industry, stabilisation of soil of rock slopes, drainage control, tunnel construction, coastal medical treatment and foundation. This paper provides an overview of the properties, functions and uses of Geo-textiles in roadway construction.
Keyword- Geo-Textiles, Pavement, Drainage, Filtration, Reinforcement

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I. INTRODUCTION

The concept of textiles was first applied to roadways in days of Pharaohs. They too faced problems of unsuitable soils, which rutted or washed away. They found that natural fibres or fabrics improved road quality when mixed with soils, particularly unstable soils. Only recently however textiles have been used and evaluated for modern roadway construction. In 1920's state of Carolina used a cotton textile to reinforce the underlying materials on a road with poor quality soils. After evaluation for several years later found the textiles provided good workable condition. They continued their work in area of reinforcement and subsequently concluded that combining cotton and asphalt materials during construction reduced cracking, ravelling, and failure of pavement and base course. Synthetic fibres became more available in 1960's. Dr. Jean Pierre Giroud introduced the original term geotextile using Latin word geo meaning soil. The word-geotextile is made up of two words- geo is related to earth and the textile word is used for fabric. During the last decade, there has been a considerable growth in the use of geotextiles all over the world.

Geotextiles have been used very successfully in road construction for over three decades. Their primary function is to separate the sub base from the sub grade resulting in stronger road construction, other functions being filtration, drainage and reinforcement. The geotextiles perform the function of separation by providing a dense mass of fibres at the interface of the two layers.

II. IMPORTANT PROPERTIES OF GEOTEXTILES

- Physical Properties

Specific gravity, Weight, Thickness, Stiffness, Density

- Mechanical Properties

Tenacity, Tensile strength, Bursting strength, Drapability, Compatibility, Flexibility, Tearing strength, Frictional resistance

- Hydraulic Properties

Porosity, Permeability, Transitivity, Soil retention, Filtration length

- Endurance Properties

Elongation, Abrasion resistance, Clogging length, Flow

III. SELECTION OF FIBRES FOR GEO-TEXTILES

Natural as well as synthetic fibres can be used as Geo-textiles for numerous applications.

A. Natural Fibres

Natural fibres are used in the form of paper strips, jute nets, wood shavings or wool mulch. In certain soil reinforcement applications, geotextiles have to serve for more than a hundred years. However bio-degradable natural geotextiles are intentionally

manufactured to possess relatively short period of life. they are generally used for prevention of soil erosion until vegetation can become properly established on the ground surface. The commonly used natural fibres are –Ramie and Jute.

B. Ramie

These fibres are subtropical bast fibres, which are obtained from their plants five to six times a year. These fibres have glossy luster and have white appearance even in the unbleached condition. They contain pure cellulose and possess highest tenacity among all plant fibres.

C. Jute

Jute is a versatile vegetable biodegradable fibre. it has the ability to combine with the soil and serve as a nutrient for vegetation. Their quick biodegradability becomes weakness for their use as a geotextile. However, their life span can be extended even up to 20 years through different treatments. Thus, it is possible to manufacture designed biodegradable jute geotextile, having specific tenacity, porosity, permeability, transmissibility according to need and site specificity. Soil, soil composition, water, water quality, water flow, landscape etc. physical scenario determines the application and selection of what kind of jute geotextiles should be used. In contrast to synthetic geotextiles, though jute geotextiles are less durable but they also have some advantages in certain area to be used particularly in agro-mulching and similar area to where quick consolidation are to take place. For erosion control and rural road considerations, soil protection from natural and seasonal degradation caused by rain, water, monsoon, wind and cold weather are vital parameters. Jute geotextiles, as separator, reinforcing and drainage activities, along with topsoil erosion in shoulder and cracking are used quite satisfactorily. Moreover, after degradation of jute geo-textiles, lignomass is formed, which increases the soil organic content, fertility, texture and also enhance vegetative growth with further consolidation and stability of soil.

D. Synthetic Fibres

The four main synthetic polymers most commonly used as the raw material for geotextiles are – Polyamide (PA), Polyester (PET), Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC), Ethylene copolymer Bitumen(ECB), Chlorinated Polyethylene(CPE). The oldest of these raw materials is polyethylene which was discovered in 1931 by ICI. Other group of polymers with a long production history is the polyamide family, the first of which was discovered in 1935. The next oldest of the four main polymer families relevant to geotextile manufacture is polyester, discovered in 1941. The most recent polymer family relevant to geotextiles was polypropylene, which was discovered in 1954

IV. TYPES OF GEOTEXTILES

The geo-textiles are manufactured in three different categories –woven geo-textiles, non-woven geo-textiles and knitted geo-textiles.

A. Woven Geotextiles

A very large numbers of geo-synthetics are of woven type, which can further be divided into several categories based upon their method of manufacture. As the name implies, they are produced by adopting techniques, similar to weaving usual clothing textiles. The Figure 1. Below shows woven geo-textiles.

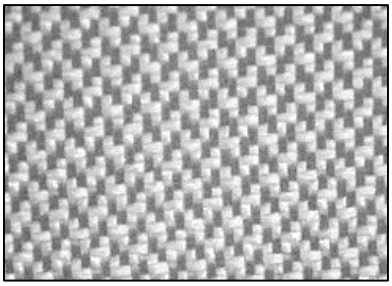

Fig. 1: Woven Geo-textiles

They have the characteristic appearance of two sets of parallel threads or yarns-the yarn running along the length is called warp and the one perpendicular is called weft. Most of low to medium strength woven geo-textiles are manufactured from polypropylene which can be in the form of extruded tape, silt film, monofilament or multifilament. Mostly a combination of yarn types is used in the warp and weft directions to optimize the performance/cost.

B. Non-Woven Geotextiles

Non woven geo-synthetics can be manufactured from short staple fibres or continuous filament yarn. The fibres are bonded together by adopting thermal, chemical or mechanical techniques or a combination of these techniques. The type of fibre (staple or continuous) used has very little effect on the properties of the non –woven geo -textiles. Non-woven geo-textiles are producedby a process of mechanical interlocking or chemical or thermal bonding of fibres/filaments. Thermally bonded non-woven geo-textiles

contain wide range of opening sizes and a typical thickness of about 0.5-1 mm. Chemically bonded non-woven geo-textiles are relatively thick usually in the order of 3 mm. While mechanically bonded non-woven geo-textiles have a typical thickness in the range of 2-5 mm and also tend to be comparatively heavy because a large quantity of polymer filament is required to provide sufficient number of interwoven filament cross fibres for sufficient bonding. The Figure 2. Below shows non-woven geo-textile.

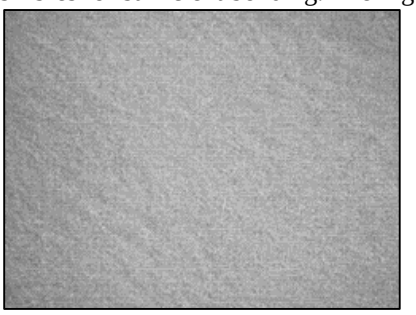

Fig. 2: Non-Woven Geo-textile

C. Knitted Geotextiles

Knitted geo-synthetics are manufactured using process which is adopted in the clothing textiles industry, named knitting. In this process, a series of loops of yarn are interconnected. Not much knitted geo-textiles are produced. All of the knitted geo-textiles are formed by using the knitting technique in combination with some other method of geo-synthetics manufacture, such as weaving. Figure 3. Below shows knitted geo-textiles.

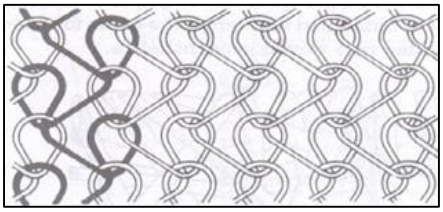

Fig. 3: Knitted Geo-textile

V. FUNCTIONS OF GEO-TEXTILES

Four primary functions have been identified in modern construction using Geo-textiles: Separation, Filtration, Drainage, and Reinforcement.

A. Separation

There often occurs problem of inter-mixing of aggregates between base and sub-base layer soil in a pavement due to the upcoming load which facilitates deformation. Geotextiles preserve the mechanical characteristics and properties of two soils of different particle size distribution and behaviour. Thus separation is defined as, “The introduction of a flexible porous textile placed between dissimilar materials so that the integrity and the functioning of both the materials can remain intact or be improved”. In current context, separation refers to the role of geotextiles in preventing the intermixing of two adjacent soils. For instance, by separating fine subgrade soil from the base course aggregates, the geotextile preserves the drainage and the strength characteristics of the aggregate material. The effect of separation is illustrated in the Figure 4. Below.

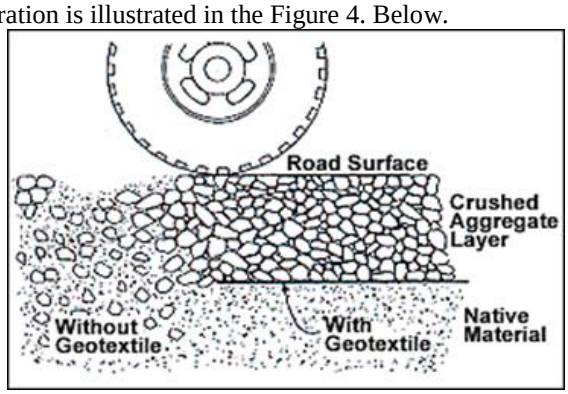

Fig. 4: Separation

B. Filtration

Filtration is the movement of water across the plane. The geo-textile acts as a filter and restores the hydraulics equilibrium by forming an auto filter with the natural soil. However, it should control but not stop completely the number of particles migrating

into the drainage media as water drains out of the soil. The geotextiles retains the filtration strata and prevents finer particles being washed out thus ensuring consistent and continuous drainage performance over a broad range of civil engineering applications. The Figure 5. Below depicts the function of filtration.

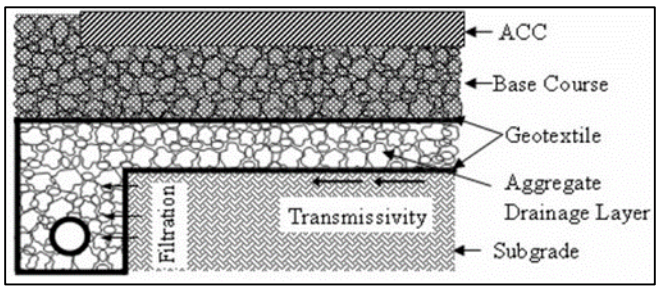

Fig. 5: Filtration and Drainage

C. Drainage

Drainage is the movement of water along the plane. A geo-textile can collect a liquid or a gas and convey it along its own plane, thus providing fluid transmission. Geo-textile is a thick drain of high porosity, which facilitates the evaluation of water in its plane and dissipating pore pressures. It has sufficient thickness, high horizontal permeability and high transmissibility, even under strong compression. Geo-textiles have a high voids ratio and it forms an auto filter with the natural soil to prevent internal erosion phenomena and avoid uplift. The figure above explains the function of drainage.

D. Reinforcement

This is the collective improvement in the total system strength created by the introduction of a geotextile into a soil. In this method, the structural stability of the soil is enhanced by the tensile strength of the material. This concept is same as to that of reinforcing concrete with steel. Concrete is weak in tension and thus reinforcing steel is used to strengthen it. Geo-textiles function in a similar manner as the reinforcing steel by providing strength that helps to hold the soil in place. Reinforcement provided by geotextiles allow the roads to be built over very weak soils. The function of reinforcement is explained in the Figure 6. Below.

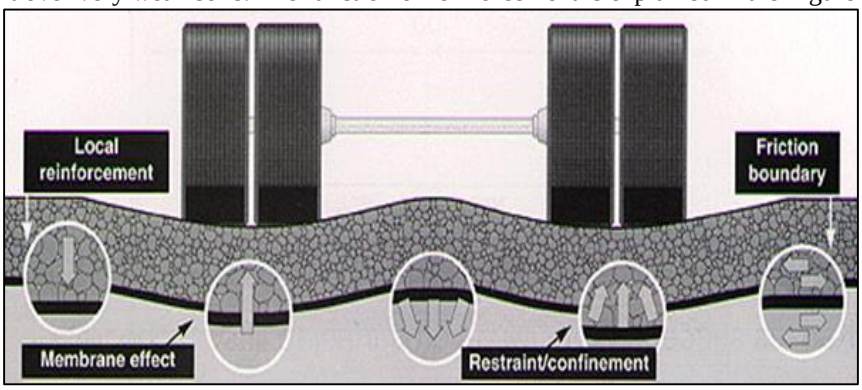

Fig. 6: Reinforcement

VI. CONCLUSION

It can be observed that Geo-textiles prove to be an effective solution to the sub-grade soil problems in roadways. Use of Geo-textiles enhance the sub-soil properties and increase the life span of a pavement. Extensive awareness should be created among the people about the uses of geo-textiles. Geo-textiles are one of the members of larger family called geosynthetics. Geo-textiles are permeable textile fabrics and may come in woven, nonwoven or knitted form. Geo-textiles are available in a variety of structures and polymeric compositions designed to meet a wide range of applications. Yet much needs to be explored about the potential of geotextile and thus more researches are needed in this field.

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