DETAIL OVERVIEW OF GEOTEXTILE & GEOMEMBRANE APPLICATIONS IN ROAD CONSTRUCTION CASE STUDY DEJEN- LUMAME ROAD PROJET

Meng project
Submitted to Addis Ababa Science and Technology University in partial fulfilment of the requirement for the degree of Master of Engineering in Road and Transport Engineering

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June, 13, 2016
This Meng project entitled with “DETAIL OVERVIEW OF GEOTEXTILE & GEOMEMBRANE APPLICATIONS IN ROAD CONSTRUCTION CASE STUDY DEJEN- LUMAME ROAD PROJET” has been approved by the following examiners in partial fulfilment of the requirement for the degree of Master of Engineering Meng in Road and Transport Engineering.

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First and foremost I would like to express my greatest gratitude to Engineer Mekonenn Tbebu (counterpart Engineer in the project) he sacrifices his time and gives me materials regarding dejen lumame road project and guide me to get additional resource from coworker’s in kajima construction corporation.

Special thanks for my beloved family and friends they help me in moral and materials.

I would also like to thank ERA staffs of central Region Ato Tamirat (counterpart Engineer in the project), Ato Yared, Ato abel, Ato Sisay and Ato Dawit for their cooperation and willingness in providing all the necessary information regarding the road.
ABSTRACT

Geosynthetics are the generally polymeric products used to solve civil engineering problems. This includes eight main product categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells and geocomposites. The wieldy applied method to improve the soil characteristic is by using geosynthetic materials which can be either Geotextile or geo membrane or Textile which function as both Geotextile and geo membrane. Geotextiles are currently specified in many different ways. From an economical point of view a complete life cycle cost analysis, which includes not only costs to agencies but also costs to users, is urgently needed to assess the benefits of using geotextile in road construction. This study concludes that the cost effectiveness shows that using the geomembrane material is cost-effective.
<table>
<thead>
<tr>
<th>Contents</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>i</td>
</tr>
<tr>
<td>Contents</td>
<td>ii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>iv</td>
</tr>
<tr>
<td>List of figures</td>
<td>v</td>
</tr>
<tr>
<td>List of abbreviation</td>
<td>vi</td>
</tr>
<tr>
<td>List of manuals</td>
<td>vii</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Objective</td>
<td>1</td>
</tr>
<tr>
<td>1.2.1 General objective</td>
<td>1</td>
</tr>
<tr>
<td>1.2.2 Specific objective</td>
<td>1</td>
</tr>
<tr>
<td>1.3 Methodology</td>
<td>2</td>
</tr>
<tr>
<td>1.4 Geotextile</td>
<td>2</td>
</tr>
<tr>
<td>1.4.1 Types of geotextile</td>
<td>3</td>
</tr>
<tr>
<td>1.4.2 Properties of geotextile</td>
<td>4</td>
</tr>
<tr>
<td>2. Applications of geotextiles</td>
<td>6</td>
</tr>
<tr>
<td>2.1 Paved Surface Rehabilitation</td>
<td>6</td>
</tr>
<tr>
<td>2.2 Reflective Crack Treatment for Pavements</td>
<td>6</td>
</tr>
<tr>
<td>2.3 Separation</td>
<td>7</td>
</tr>
<tr>
<td>2.4 Filtration</td>
<td>10</td>
</tr>
<tr>
<td>2.5 Drainage (Transmissivity)</td>
<td>11</td>
</tr>
<tr>
<td>2.6 Reinforcement</td>
<td>12</td>
</tr>
<tr>
<td>2.7 Sealing Function</td>
<td>12</td>
</tr>
<tr>
<td>3. Design Consideration of geotextiles</td>
<td>14</td>
</tr>
<tr>
<td>3.1 Woven Geotextiles</td>
<td>14</td>
</tr>
<tr>
<td>3.2 Nonwoven Geotextiles</td>
<td>15</td>
</tr>
<tr>
<td>3.3 Construction Consideration of geotextiles</td>
<td>15</td>
</tr>
<tr>
<td>4. The case of Dejen–Lumame road project</td>
<td>19</td>
</tr>
<tr>
<td>4.1 Application Of geomembrane road project</td>
<td>19</td>
</tr>
<tr>
<td>4.1.1 Geomembranes</td>
<td>21</td>
</tr>
</tbody>
</table>


LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1.1 Minimum Geotextile Strength Properties for Survivability</td>
<td>5</td>
</tr>
<tr>
<td>Table 2-1 Construction Survivability Ratings (FHWA 1989)</td>
<td>8</td>
</tr>
<tr>
<td>Table 2-2 Relationship of Construction Elements to Severity of Loading Imposed on Geotextile in Roadway Construction</td>
<td>9</td>
</tr>
<tr>
<td>Table 2.3 Areas of application of geo textile</td>
<td>13</td>
</tr>
<tr>
<td>Table 3.1 Recommended Geotextile Overlap, (user guide line for geotextile1991)</td>
<td>17</td>
</tr>
<tr>
<td>Table 3.2 Recommended minimum overlap requirements (geotextile design guide lines, FM 5-430-00-1/AFPAM 32-8013, Vol 1)</td>
<td>17</td>
</tr>
<tr>
<td>Table 3.3 Requirement for woven geotextiles, (user guide line for geotextile, 1991)</td>
<td>17</td>
</tr>
<tr>
<td>Table 3.4 Requirement for non-woven geotextiles, (user guide line for geotextile, 1991)</td>
<td>18</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1 Geotextile</td>
<td>2</td>
</tr>
<tr>
<td>Figure 1.2 Non-Woven geotextile</td>
<td>3</td>
</tr>
<tr>
<td>Figure 1.3 Woven geotextile</td>
<td>4</td>
</tr>
<tr>
<td>Figure 2.1 Relationships between Shear Strength, CBR, and Cone Index</td>
<td>8</td>
</tr>
<tr>
<td>Figure 2.2 Separation</td>
<td>10</td>
</tr>
<tr>
<td>Figure 2.3 Filtration</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2.4 Drainage</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2.5 Reinforcement</td>
<td>12</td>
</tr>
<tr>
<td>Figure 2.6 Sealing function</td>
<td>13</td>
</tr>
<tr>
<td>Figure 4.1 Map of route Dejen – Lumame road project</td>
<td>19</td>
</tr>
<tr>
<td>Figure 4.2 Process of Application of LDPE in Dejen- Lumame road Project</td>
<td>21</td>
</tr>
<tr>
<td>Figure 4.3 black cotton replacement works</td>
<td>22</td>
</tr>
<tr>
<td>Figure 4.4 Cross section of road type A</td>
<td>25</td>
</tr>
<tr>
<td>Figure 4.5 Cross section of road Type B</td>
<td>26</td>
</tr>
<tr>
<td>Figure 4.6 Cross section of road type C</td>
<td>27</td>
</tr>
<tr>
<td>Figure 4.7 Cross section of road type C’</td>
<td>29</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>AASHTO</td>
<td>American association state of highway and transport officials</td>
</tr>
<tr>
<td>ADS</td>
<td>Agricultural development system</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Soil test Method</td>
</tr>
<tr>
<td>AOS</td>
<td>Apparent opening size</td>
</tr>
<tr>
<td>CBR</td>
<td>California bearing ratio</td>
</tr>
<tr>
<td>$D_f$</td>
<td>Filament thickness</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental protection agency</td>
</tr>
<tr>
<td>ERA</td>
<td>Ethiopia road authority</td>
</tr>
<tr>
<td>LDPE</td>
<td>Low Density Polyethylene waterproofing sheets</td>
</tr>
<tr>
<td>$O_f$</td>
<td>Filtration opening</td>
</tr>
<tr>
<td>$O_{90}$</td>
<td>Fabric opening size below which 90% of pores is smaller</td>
</tr>
<tr>
<td>PF</td>
<td>Primary Function</td>
</tr>
<tr>
<td>POA</td>
<td>Percent of opening area</td>
</tr>
<tr>
<td>SF</td>
<td>Secondary Function</td>
</tr>
</tbody>
</table>
LIST OF MANUALS

FHWA ................................................................. designing with geosynthetic

ASCE ................................................................. American Society of Civil Engineers

ASTM-D3786 ...................................................... the force or pressure required to rupture fabric

ASTM-D4355 .................. for measure of the potential for the deterioration of tensile strength

ASTM-D4595 ........................... for the stretching or elongation of a geotextile when measured at the point

ASTM-D4751 ...................................................... to determined maximum size opening

ASTM-D4833 ............................... for the force required to penetrate or rupture a fabric
1. Introduction

Now days in civil Engineering, construction of any structure is possible. This is due to the advancement in increasing the strength of materials used in construction. Mega structures are built due to the development of Reinforcement in concrete. This reinforcement has similar concept in improving the characteristics of soil in geotechnical Engineering. The wieldy applied method to improve the soil characteristic is by using geosynthetic materials which can be either Geotextile or geo membrane or Textile which function as both Geotextile and geo membrane.

Geosynthetics are the generally polymeric products used to solve civil engineering problems. This includes eight main product categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells and geocomposites. The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. Properly formulated, however, they can also be used in exposed applications. Geosynthetics are available in a wide range of forms and materials, each to suit a slightly different end use. These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, geo environmental, hydraulic, and private development applications including roads, airfields, railroads, and embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners, landfill covers, mining, aquaculture and agriculture.

1.1 Scope

This paper covers physical properties, functions, design considerations, construction considerations for geotextiles. Geotextile have different functions such as; separation, filtration and drainage, reinforced road embankments. Taking the case study Dejen- Lumame road Rehabilitation project as a case study evaluating its profitability and discuss the purpose of Geo-membrane especially LDPE which is applied in the project.

1.2 Objective

1.2.1 General objective

The main objective of this study is to assess the Applicability and compare the overall cost of geotextile when they applied in Ethiopia.

1.2.2 Specific objective

- To introduce the applicability of geo textiles in Ethiopia.
- To know what kind of textile material is applied in dejen-Lumame road project regarding to the specific application of textile.
- To create awareness regarding the current usage of geosynthetic nowadays.
- To compare the total cost of the project using geotextile material and other alternative methods.
1.3 Methodology
The following methodology has been employed to achieve the objectives of the research:

- Literature survey has been conducted the review includes text books, periodicals and academic journals, seminars, and research papers.
- Taking Dejen- Lumame as case study the application of LDPE and suitability of the application.
- And finally formulation of conclusion and recommendations based on the review and the case study.

1.4 Geotextile
Geotextiles form one of the two largest groups of geosynthetics. Their rise in growth during the past 35 years has been nothing short of extraordinary. They are indeed textiles in the traditional sense, but they consist of synthetic fibers rather than natural ones such as cotton, wool, or silk. Thus bio degradation and subsequent short lifetime is not a problem. Geotextiles were originally intended to be an alternative to granular soil filters. The original, and still sometimes used, term for geotextiles is filter fabrics. Work originally began in the 1950s with (Barret, R. J, 1966) [2] using geotextiles behind precast concrete seawalls, under precast concrete erosion control blocks, beneath large stone riprap, and in other erosion control situations (Barret, R. J, 1966) [2] He used different styles of woven monofilament fabrics, all characterized by a relatively high percentage open area (varying from 6 to 30%). He discussed the need for both adequate permeability and soil retention, along with adequate fabric strength and proper elongation and set the tone for geotextile use in filtration situations

Figure 1.1 geotextile
1.4 Types of geotextile

There are two principal geotextile types, or structures: woven and nonwovens. Other manufacturing techniques, for example knitting and stitch bonding are occasionally used in the manufacture of specialty products.

1.4.1 Nonwovens geotextiles

When building a road, designing an erosion control plan or installing a subsurface drainage system, ADS needle punched nonwoven geotextiles have proven benefits. The nonwoven geotextiles are approved by local, state and federal agencies, including the Federal Highway Administration, U.S. Army Corps of Engineers, the EPA and AASHTO. Nonwoven geotextiles are manufactured from either staple fibers (staple fibers are short, usually 1 to 4 inches in length) or continuous filaments randomly distributed in layers onto a moving belt to form a felt-like "web". The web then passes through a needle loom and/or other bonding machine interlocking the fibers/filaments. Nonwoven geotextiles are highly desirable for subsurface drainage and erosion control applications as well as for road stabilization over wet moisture sensitive soils.

![Figure 1.2 Non-Woven geotextile](image)

1.4.2 Woven geotextiles

Weaving is a process of interlocking yarns to make a fabric. Woven geotextiles are made from weaving monofilament, multifilament, or slit film yarns. Slit film yarns can be further subdivided into flat tapes and fibrillated (or spider web-like) yarns. There are two steps in this process of making a woven geotextile: first, manufacture of the filaments or slitting the film to create yarns; and second, weaving the yarns to form the geotextile. Slit film fabrics are normally used for sediment control, i.e. silt fence, and road stabilization applications but are poor choices for subsurface drainage and erosion control applications. Due to the structure of the flat tape slit film yarns, these fabrics have relatively poor permeability. However, fabrics made with fibrillated tape yarns are usually stronger and have better permeability than flat tape products.
1.4.2 Properties of geotextile

**Tensile strength:** This property is measured by a grab test method. It determines the effective strength of the fabric when subjected to forces that tend to pull the fabric apart. (ASTM-D4595). The tensile strength of geotextiles and related materials is a very important property as virtually all applications rely on it either as the primary or secondary function. This test is useful for quality control and can also be used for design purposes.

**Puncture Strength of Geotextiles**- The force required to penetrate or rupture a fabric with a small rounded projectile. (ASTM-D4833) The results of this test can also be used to assess the fabric's resistance to aggregate penetration, particularly in separation applications.

**Elongation**- The stretching or elongation of a geotextile when measured at the point of failure or rupture of the fabric during the tensile strength test. (ASTM-D4595)

**Bursting Strength** - The force or pressure required to rupture fabric by an expanding diaphragm over which the fabric is clamped. (ASTM-D3786)

**Apparent Pore Size Distribution by Dry Sieving:** (AOS) O₉₅ - The approximate size of the largest particle that would effectively pass through the geotextile. The pore size distribution of the fabric is determined by sieving dry spherical solid glass beads for a specified time at a specified frequency of vibration and then measuring the amount retained by the fabric sample. The test is carried out on a range of sizes of glass beads. In addition, the apparent opening size (O₉₀) is determined, this being the pore size at which 90% of the glass beads are retained on and within the fabric. This test provides information on the pore size distribution which is an important parameter to be used in assessing geotextile's soil filtration capability. (Dr K C Yeo, Castco Testing Centre Limited, Hong Kong) [3].

**Percent Open Area (POA) Determination for Woven Geotextiles**: A small section of the fabric is held within a standard slide cover, inserted into a projector and the magnified image traced on to a sheet of paper. Using a plan meter, the magnified open spaces can be measured and expressed as a percentage of whole area. The test is primarily applicable to monofilament
woven fabrics. The test provides information on pore size openings which is important in assessing a geotextile’s soil filtration capability. (CWO-02215-86 Corp of Engineers) (Dr K C Yeo, Castco Testing Centre Limited, Hong Kong) [3].

**Ultraviolet Light Resistance** - A measure of the potential for the deterioration of tensile strength in the fabric due to exposure to ultraviolet light and water. (ASTM-D4355)

Table 1.1 Minimum Geotextile Strength Properties for Survivability.

<table>
<thead>
<tr>
<th>Required Degree Of Geotextile Survivability</th>
<th>Grab Strength (lb)</th>
<th>Puncture Strength (lb)</th>
<th>Burst Strength (Psi)</th>
<th>Trap Tear (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>270</td>
<td>110</td>
<td>430</td>
<td>75</td>
</tr>
<tr>
<td>High</td>
<td>180</td>
<td>75</td>
<td>290</td>
<td>50</td>
</tr>
<tr>
<td>Moderate</td>
<td>130</td>
<td>40</td>
<td>210</td>
<td>40</td>
</tr>
<tr>
<td>Low</td>
<td>90</td>
<td>30</td>
<td>145</td>
<td>30</td>
</tr>
</tbody>
</table>

Note: All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the minimum values in this table). These values are normally 20 percent lower than manufacturers reported typical values.
2. Applications of geotextiles

Every textile product applied under the soil is a geotextile. The products are used for reinforcement of streets, embankments, ponds, pipelines, and similar applications. Depending on the required function, they are used in open-mesh versions, such as a woven or, rarely, warp-knitted structure, or with a closed fabric surface, such as a non-woven. The mode of operation of a geotextile in any application is defined by six discrete functions: separation, filtration, drainage, reinforcement, sealing, and protection. Depending on the application, the geotextile performs one or more of these functions simultaneously.

2.1 Paved Surface Rehabilitation

Old and weathered pavements contain transverse and longitudinal cracks that are both temperature and load related. The method most often used to rehabilitate these pavements is to overlay the pavement with AC. This temporarily covers the cracks. After the overlay has been placed, any lateral or vertical movement of the pavement at the cracks due to load or thermal effects causes the cracks from the existing pavement to propagate up through the new AC overlay (called reflective cracking). This movement causes raveling and spilling along the reflective cracks and provides a path for surface water to reach the base and subgrade which decreases the ride quality and accelerates pavement deterioration.

Under an AC overlay, a geotextile may provide sufficient tensile strength to relieve stresses exerted by movement of the existing pavement. The geotextile acts as a stress-relieving interlayer as the cracks move horizontally or vertically. Impregnation of the geotextile with bitumen provides a degree of moisture protection for the underlying layers whether or not reflective cracking occurs.

2.2 Reflective Crack Treatment for Pavements

Geotextiles can be used successfully in pavement rehabilitation projects. Conditions that are compatible for the pavement applications of geotextiles are AC pavements that may have transverse and longitudinal cracks but are relatively smooth and structurally sound, and PCC pavements that have minimum slab movement. The geographic location and climate of the project site have an important part in determining whether or not geotextiles can be successfully used in pavement rehabilitation. Geotextiles have been successful in reducing and retarding reflective cracking in mild and dry climates when temperature and moisture changes are less likely to contribute to movement of the underlying pavement; whereas, geotextiles in cold climates have not been as successful. Even when the climate and thickness requirements are met, there has been no consistent increase in the time it takes for reflective cracking to develop in the overlay indicating that other factors are influencing performance. Other factors affecting performance of geotextile interlayer’s are construction techniques involving pavement preparation, asphalt sealant application, geotextile installation, and AC overlay as well as the condition of the underlying pavement.

Prior to using geotextiles to minimize reflective cracks, the existing pavement should be evaluated to determine pavement distress. The size of the cracks and joints in the existing pavement should be determined. All cracks and joints larger than ¼ inch in width should be sealed. Differential slab movement should be evaluated, since deflections greater than 0.002 inch cause early reflective cracks. Areas of the pavement that are structurally deficient should be repaired prior to geotextile installation. Placement of a leveling course is recommended when the existing pavement is excessively cracked and uneven.

Geotextile Selection:
Geotextile interlayer’s are used in two different capacities— the full-width and strip methods. 
(1) The full-width method involves sealing cracks and joints and placing a nonwoven material across the entire width of the existing pavement.
Nonwoven materials provide more flexibility and are recommended for reflective crack treatment of AC pavements.
(2) The strip method is primarily used on PCC pavements and involves preparing the existing cracks and joints, and placing a 12 to 24 inch wide geotextile and sufficient asphalt directly on the cracks and joints.
Nonwoven geotextiles are not normally used in the strip method. Membrane systems have been developed for strip repairs.
Asphalt Sealant. The asphalt sealant is used to impregnate and seal the geotextile and bond it to both the base pavement and overlay. The grade of asphalt cement specified for hot-mix AC pavements in each geographic location is generally the most acceptable material. Either anionic or cationic emulsion can also be used. Cutback asphalts and emulsions which contain solvents should not be used.
AC Overlay. For AC pavements the minimum thickness of an AC overlay for geotextile application on PCC pavements is 4 inches.
Spot Repairs. Rehabilitation of localized distressed areas and utility cuts can be improved with the application of geotextiles. Isolated distressed areas that are excessively cracked can be repaired with geotextiles prior to an AC overlay. Either a full-width membrane strip application can be used depending on the size of the distressed area. Localized distressed areas of existing AC pavement that are caused by base failure should be repaired prior to any pavement rehabilitation. Geotextiles are not capable of bridging structurally deficient pavements.

2.3 Separation
Soft sub grade materials may mix with the granular base or sub base material as a result of loads applied to the base course during construction and/or loads applied to the pavement surface that force the granular material downward into the soft sub grade or as a result of water moving upward into the granular material and carrying the sub grade material with it. 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”. (Koerner, 1994) [1].

In transportation applications separation refers to the geotextile’s role in preventing the intermixing of two adjacent soils. In paved and unpaved roadways where granular aggregate is placed on fine-grained soils, two detrimental mechanisms occur over time without the use of a geotextile separator:

i. First, the fine-grained soils enter into the voids of the granular aggregate, preventing it from draining properly and the aggregate loses the required rock-to-rock contact, greatly diminishing the strength of the aggregate support layer and accelerating road failure.

ii. Second, the granular aggregate punches into the fine-grained soil, thereby decreasing the effective thickness of the aggregate layer.

The soil retention properties of the geotextile are basically the same as those required for drainage or filtration. Therefore, the retention and permeability criteria required for drainage should be met. In addition, the geotextile should withstand the stresses resulting from the load applied to the pavement. The nature of these stresses depends on the condition of the sub grade,
type of construction equipment, and the cover over the sub grade. Since the geotextile serves to prevent aggregate from penetrating the sub grade, it must meet puncture, burst, grab and tear strengths. The soil strength to an equivalent cohesion (C) value using the correlation shown in figure below. The shear strength is equal to the C value.

Figure 2.1 Relationships between Shear Strength, CBR, and Cone Index.

Table 2-1 Construction Survivability Ratings (FHWA 1989)

<table>
<thead>
<tr>
<th>Site Soil CBR At Installation (psi)</th>
<th>&lt;1</th>
<th>1-2</th>
<th>&gt;2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover Thickness (in.) (Compacted)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>NR</td>
<td>NR</td>
<td>H</td>
</tr>
<tr>
<td>6</td>
<td>NR</td>
<td>NR</td>
<td>H</td>
</tr>
<tr>
<td>12</td>
<td>NR</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>18</td>
<td>H</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>H = High, M = Medium, NR = Not recommended.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maximum aggregate size not to exceed one half the compacted covers thickness. For low volume unpaved road (ADT 200 vehicles). The four inch minimum cover is limited to existing road bases and not intended for use in new construction.

Table 2-2 Relationship of Construction Elements to Severity of Loading Imposed on Geotextile in Roadway Construction

<table>
<thead>
<tr>
<th>Variable</th>
<th>Severity Category</th>
<th>Low</th>
<th>Moderate</th>
<th>High to very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td></td>
<td>Light weight dozer (8 psi)</td>
<td>Medium weight dozer; light wheeled equipment (8-40 psi)</td>
<td>Medium weight Heavy weight dozer; loaded dump truck (&gt;40 psi)</td>
</tr>
<tr>
<td>Subgrade Condition</td>
<td></td>
<td>Cleared</td>
<td>Partially cleared</td>
<td>Not cleared</td>
</tr>
<tr>
<td>Subgrade Strength (CBR)</td>
<td></td>
<td>&lt;0.5</td>
<td>1-2</td>
<td>&gt;3</td>
</tr>
<tr>
<td>Aggregate</td>
<td></td>
<td>Rounded sandy gravel</td>
<td>Coarse angular gravel</td>
<td>Cobble, blasted rock</td>
</tr>
<tr>
<td>Lift Thickness (in.)</td>
<td></td>
<td>18</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

The cost of the installed separation geotextile is typically less than the cost of 1 inch of base course aggregate; separation geotextiles typically prevent contamination of several inches of base aggregate. Therefore, the benefit significantly outweighs the cost of using a separation geotextile in pavements. As early as 1994, a joint American Association of State Highway and Transportation Officials (AASHTO) industry task force identified “quantifying life cycle cost-benefit of pavements incorporating geotextile separators” as a top priority research need for the transportation industry. Local and state studies have proven that the use of geotextiles as separators has enhanced road performance as a result of the placement of the geotextile between the sub grade and the pavement aggregate base layer. Studies show the extended life of pavement sections that incorporate geotextiles. These studies have shown reduced long-term maintenance and reduced pavement rehabilitation costs for roads using geotextiles.
2.4 Filtration

It is defined as “the equilibrium geotextile-to-soil system that allows for adequate liquid flow with limited soil loss across the plane of the geotextile over a service lifetime compatible with the application under consideration”. In filtration, fabrics can be either woven or non-woven, to permit the passage of water while retaining soil particles. Porosity and permeability are the major properties of geotextiles which involves infiltration action. Application helps the replacement of graded aggregate filters by a geotextiles warping. These applications are also suitable for both horizontal and vertical drains.

In addition to retention and permeability criteria, several other considerations are required for geotextile filter design. Some considerations are noted below:

**Retention**: Ensures that the geotextile openings are small enough to prevent excessive migration of soil particles.

**Permeability**: Ensures that the geotextile is permeable enough to allow liquids to pass through without causing significant upstream pressure buildup.

**Anti-clogging**: Ensures that the geotextile has adequate openings, preventing trapped soil from clogging openings and affecting permeability.

**Survivability**: Ensures that the geotextile is strong enough to resist damage during installation.

**Durability**: Ensures that the geotextile is resilient to adverse chemical, biological and ultraviolet (UV) light exposure for the design life of the project.

A common application illustrating the filtration function is the use of a geotextile in a pavement edge drain, as shown in figure 2.3
2.5 Drainage (Transmissivity)

This refers to the ability of thick nonwoven geotextile whose three-dimensional structure provides an avenue for flow of water through the plane of the geotextile. The above figure also illustrates the transmissivity function of geotextile. Here the geotextile promotes a lateral flow thereby dissipating the kinetic energy of the capillary rise of ground water.
2.6 Reinforcement

Geotextile reinforcement is defined as the synergistic improvement of a total system's strength created by the introduction of a geotextile (good in tension) into a soil (good in compression but poor in tension) or other disjointed and separated material (Koerner, 1994) [1].

The concept is similar to that of reinforcing concrete with steel. Since concrete is weak in tension, reinforcing steel is used to strengthen it. Geosynthetic materials function in a similar manner as the reinforcing steel by providing strength that helps to hold the soil in place. Reinforcement provided by geotextiles embankments and roads to be built over very weak soils and allows for steeper embankments to be built. In paved and unpaved roadway applications, geotextiles provide tensile reinforcement through frictional interaction with base course materials, thereby reducing applied stresses on the sub grade and preventing rutting caused by sub grade overstress.

Properly selected woven and nonwoven geotextiles provide reinforcement in roadways. However, woven geotextiles typically have a higher tensile modulus than a comparable nonwoven. By providing high tensile strength at low strains (i.e., high modulus) woven geotextiles generally are considered better reinforcement materials than nonwoven geotextiles which typically provide high strength at high elongations (low modulus). Therefore, benefits derived from the reinforcement function are dependent on the amount of system deformation allowed. In unpaved roads, a large amount of deformation is sometimes allowed and the reinforcement function of a geotextile can provide significant benefits. In paved roads, allowable system deformation is usually very low and, as a result, reinforcement is generally not considered to be applicable in most paved roadways but separation and stabilization are still key functions.

![Figure 2.5 Reinforcement](image)

2.7 Sealing Function

When reinforced, significant tensile stresses can be carried by the reinforcement, resulting in a composite structure which possesses wider margins of strength. A non-woven geotextile performs this function when impregnated with asphalt or other polymeric mixes rendering it relatively impermeable to both cross-plane and in-plane flow. Here the non-woven geotextile is
placed on the existing pavement surface following the application of an asphalt tack coat. The geotextile absorbs asphalt to become a waterproofing membrane minimizing vertical flow of water into the pavement structure.

Figure 2.6 sealing function

Table 2.3 Areas of application of geo textile

<table>
<thead>
<tr>
<th>Areas Application</th>
<th>Separation</th>
<th>Filtration</th>
<th>Drainage</th>
<th>Reinforcement</th>
<th>Protection</th>
<th>Water proofing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved Roads</td>
<td>PF</td>
<td>SF</td>
<td>SF</td>
<td>SF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unpaved Roads</td>
<td>PF</td>
<td>SF</td>
<td>SF</td>
<td>SF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repaving</td>
<td></td>
<td></td>
<td>SF</td>
<td>PF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage</td>
<td>PF</td>
<td>PF</td>
<td>SF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sports Fields</td>
<td>PF</td>
<td>PF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Construction</td>
<td>SF</td>
<td>PF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railroads</td>
<td>PF</td>
<td>PF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geomembrane Containment</td>
<td></td>
<td>SF</td>
<td>SF</td>
<td>PF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embankments</td>
<td>PF</td>
<td>SF</td>
<td>SF</td>
<td>SF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retaining Walls</td>
<td></td>
<td>SF</td>
<td>PF</td>
<td>PF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tunnels</td>
<td></td>
<td></td>
<td></td>
<td>PF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PF: Primary Function    SF: Secondary Function
3. Design Consideration of geotextiles

These benefits derived from these four geotextile functions are most significant when sub grade soils are weak, i.e., CBR < 3. However, long-term benefits (improved pavement performance over time) from separation in applications where the sub grade is competent, (i.e., CBR >3), are just now beginning to surface, as roads 30 years old have been unearthed and have maintained their full structural section since they were built over a geotextile.

In case of filtration, the designer must specify geotextile properties that will allow retention of the soil being protected while allowing sufficient flow through the geotextile, and prevent clogging. Woven geotextile requires more critical evaluation and analysis than nonwovens and the following guidelines are recommended for determining requirements. (Koerner, 1994) [1].

3.1 Woven Geotextiles

The apparent opening size (AOS) is critical while the geotextile fabric serves as a filter, or if seepage gradients are significant. It is also critical if the geotextile fabric protects underlying soils from erosion, and flow or splash characteristics could affect the underlying base soil. The AOS test provides a means of evaluation the retention characteristics of a geotextile while POA provides a measure of flow through the geotextile and adequate resistance to any reduction in permeability over time (clogging). POA is used only for woven geotextiles. Since the POA data is obtained from laboratory evaluations without soil covering the geotextile, it is an index test and doesn't provide a direct measure of field performance. The base soil gradation must be known. If the base soil has particles larger than 4.75mm sieve, the gradation of the base soils must first be re-graded. The following recommendations then apply to the re-graded soil.

Soils with more than 85% passing 0.075mm sieve

Do not use a woven geotextile adjacent to these soils. A layer of fine sand must be used between the base soil and the geotextile if a woven geotextile is to be used. The AOS of the geotextile is then determined considering the sand used as the base soil. (User guide line for geotextile 1991) [5].

Soils with 51-85% finer than 0.075mm sieve

The AOS should be no larger than the openings in the 0.212mm sieve, and no smaller than the openings in 0.15mm sieve for proper soil retention. For added clogging, the POA should be ≥4%. Percent open area (POA) is the ratio of open area to total area of woven geotextile.

Giroud (1996) proposed that POA as:

\[
POA(\%) = \left(\frac{Of}{Of+df}\right)^2
\]

POA where \(df\) is the filament thickness, and \(Of\) is the filtration opening size. \(Of\) is largest pore-opening size of a particular geotextile. For permeability, \(k\) of the geotextile > \(k\) (soil)

Soils with 15 to 50% finer than 0.075mm sieve.

The AOS of the geotextile should be less than or equal to 1.0 times the \(d_{85}\) of the base soil. The
POA should be 4% or greater. For permeability, k of the geotextile > 10k (soil)

**Soils with less than 15% finer than 0.075mm sieve**
The AOS of the geotextile should be less than or equal to 2.0 times the d85 of the base soil. The percent opening area (POA) should be 6% or greater. The POA should be as large as possible up to 30% for available geotextiles that meet the above criteria for this category of base soils. For permeability, k of the geotextile > 10k (soil)

**In general, to reduce the possibility of clogging,**
The geotextile should not be specified with an AOS smaller than 0.15mm sieve size. If the criteria in 2, 3, or 4 above results in an AOS smaller than 0.15mm sieve size, laboratory tests will be necessary for evaluating the clogging potential for a specific base soil and geotextile combination. The AOS for each category should be as large as possible without exceeding the criteria listed.

### 3.2 Nonwoven Geotextiles

Apparent Opening Size (AOS) is not a controlled property with nonwoven geotextiles. These geotextiles have a wide range of size openings.

The maximum size opening should be no larger than 0.425mm sieve size. (As determined by methods in ASTM-D4751.)

In general, nonwoven geotextiles retain more soil fines than do woven geotextiles. The structure of the mechanically bonded needle-punched fabric helps to decrease the internal fabric clogging potential.

The nonwoven geotextiles have very good permeability characteristics and should be strongly considered where seepage flows are a concern.

Nonwoven fabrics have a rougher surface than woven. Therefore, the bond between the soil and the fabrics offer more resistance to sliding along the plane of contact.

### 3.3 Construction Consideration of geotextiles

Effective performance of the selected geotextile is greatly dependent on the installation procedures and field preparation of the surface to be protected. When geotextile fabrics are used adjacent to fill or backfill, the fill soil placement is critical in preventing conditions subject to plugging of the fabric.

The following techniques help minimize the movement of soils particles toward the fabric surface and provide more area for flow through the fabric.

- Prepare soil surfaces adjacent to fabrics so that all flow channels or voids larger than the openings in the fabric are eliminated.
- Utilize soil compaction and placement techniques to ensure that intimate contact between the fabric and the soil is maintained.
- Provide a surface area as large as possible for the filter (i.e., it is better to place the geotextile around the periphery of the drain trench with gravel and pipe inside than to place the fabric around the pipe where the surface area is smallest).

**Additional construction considerations** specific to the function or type of application are:

**Slope Protection** - Class I and II. The method of placement of rock or other material on the geotextile may have to be specified. Placement should be accomplished by equipment capable of controlling the drop. Pushing or rolling rock over the geotextile should not be allowed. The maximum drop is 3 feet for protected or unprotected geotextile. Where conditions require a larger drop, the strength of the geotextile and/or thickness of mitigating materials need to be increased.

**Class I - Unprotected** - limits the height for dropping stone onto bare geotextile to 3 feet.

**Class II - Protected** - require the use of 6 inch sand or soil cushion for bedding the stone on the geotextile, and limit the height of drop to 3 feet.

**Subsurface Drainage** -Class III

a) The Tables below are intended for normal operating conditions where material will not be dropped more than five feet onto the geotextile, where trench depths from the normal ground surface will be no deeper than ten and sharp, angular aggregates are not used.

b) The materials listed in the Tables below are for average conditions. When the materials are used in trenches deeper than ten feet or with sharp, angular aggregates, heavier geotextiles are recommended; tensile strength should be increased to 150 lbs minimum, burst strength should be increased to 300 psi minimum.

c) To prevent movement of surface soil where groundwater and seepage pressures are a factor, the geotextile must be in intimate contact with the sub grade soil.

d) Voids between the geotextiles and the base soil need to be minimized to prevent the collecting of fines behind the fabric and subsequent clogging.

e) The geotextile should be pulled flat during installation to eliminate wrinkles and folds that create voids.

f) If flow in the plane of the geotextile is a concern in the drain installation, the type and thickness of the fabric becomes an important criterion. A heavier weight nonwoven needle punched fabric should be used.

g) **Road Stabilization** - Class IV (as indicated in Tables below).

h) Tables 1 and 2 below are intended for light to medium loading in both weight and frequency of traffic.

i) If the sub grade is soft and it is determined in design that the potential for rutting is high, the minimum overlap should be increased to the following:
Table 3.1 Recommended Geotextile Overlap, (user guide line for geotextile1991) [8].

<table>
<thead>
<tr>
<th>Blow count</th>
<th>Overlap (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>4—9</td>
<td>36</td>
</tr>
<tr>
<td>&lt;4</td>
<td>48</td>
</tr>
</tbody>
</table>

Table 3.2 Recommended minimum overlap requirements, (geotextile design guide lines, FM 5-430-00-1/AFPAM 32-8013, Vol 1) [9].

<table>
<thead>
<tr>
<th>CBR</th>
<th>Minimum Overlap (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2</td>
<td>1—1.5</td>
</tr>
<tr>
<td>1—2</td>
<td>2—3</td>
</tr>
<tr>
<td>0.5-1</td>
<td>3</td>
</tr>
<tr>
<td>&lt;0.5</td>
<td>1</td>
</tr>
<tr>
<td>All roll ends</td>
<td>3</td>
</tr>
</tbody>
</table>

A class of geotextile should be selected based on the intended use with appropriate considerations for construction and installation methods.

Table 3.3 Requirement for woven geotextiles, (user guide line for geotextile, 1991) [5].

<table>
<thead>
<tr>
<th>Property</th>
<th>test method</th>
<th>class I</th>
<th>class II&amp;III</th>
<th>class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>tensile strength (pounds) min.</td>
<td>ASTM D 4632 Grab test</td>
<td>200mm in any principal direction</td>
<td>120mm in any principal direction</td>
<td>180mm in any principal direction</td>
</tr>
<tr>
<td>bursting strength (psi) min.</td>
<td>ASTM D 3786 Diaphragm tester</td>
<td>400 min.</td>
<td>300min.</td>
<td>NA</td>
</tr>
<tr>
<td>elongation @failure(%)min.</td>
<td>ASTM D 4632 Grab test</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Puncture strength (pounds) min.</td>
<td>ASTM D 4833</td>
<td>90min.</td>
<td>60min.</td>
<td>60min.</td>
</tr>
<tr>
<td>ultra violate light(%) residual tensile strength</td>
<td>ASTM D 4355 150 hours exposure</td>
<td>70min.</td>
<td>70min.</td>
<td>70min.</td>
</tr>
<tr>
<td>AOS</td>
<td>ASTM D 4751</td>
<td>as specified or a min 0.15mm sieve size</td>
<td>as specified or a min 0.15mm sieve size</td>
<td>as specified or a min 0.15mm sieve size</td>
</tr>
<tr>
<td>Percent opening size (%)</td>
<td>CWO-02215-86</td>
<td>4min</td>
<td>4min</td>
<td>1min</td>
</tr>
<tr>
<td>permittivity (1/seconds)</td>
<td>ASTM D 4491</td>
<td>0.1min.</td>
<td>0.1min.</td>
<td>0.1min.</td>
</tr>
</tbody>
</table>
Table 3.4 Requirement for non-woven geotextiles, (user guide line for geotextile, 1991) [5].

<table>
<thead>
<tr>
<th>Property</th>
<th>test method</th>
<th>class I</th>
<th>class II</th>
<th>class III</th>
<th>class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>tensile strength (pounds) min.</td>
<td>ASTM D 4632</td>
<td>180mm in any principal direction</td>
<td>120mm in any principal direction</td>
<td>90mm in any principal direction</td>
<td>115mm in any principal direction</td>
</tr>
<tr>
<td></td>
<td>Grab test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bursting strength (psi) min.</td>
<td>ASTM D 3786</td>
<td>320 min.</td>
<td>210min.</td>
<td>180min.</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Diaphragm tester</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>elongation @ failure(%)min.</td>
<td>ASTM D 4632</td>
<td>&gt;50</td>
<td>&gt;50</td>
<td>&gt;50</td>
<td>&gt;50</td>
</tr>
<tr>
<td></td>
<td>Grab test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>puncture (pounds) min.</td>
<td>ASTM D 4833</td>
<td>80min.</td>
<td>60min.</td>
<td>40min.</td>
<td>40min.</td>
</tr>
<tr>
<td>ultra violate light(% residual tensile strength)</td>
<td>ASTM D 4355 150 hours exposure</td>
<td>70min.</td>
<td>70min.</td>
<td>70min.</td>
<td>70min.</td>
</tr>
<tr>
<td>AOS</td>
<td>ASTM D 4751</td>
<td>as specified or a min 0.425mm sieve size</td>
<td>as specified or a min 0.425mm sieve size</td>
<td>as specified or a min 0.425mm sieve size</td>
<td>as specified or a min 0.425mm sieve size</td>
</tr>
<tr>
<td>permittivity (1/seconds)</td>
<td>ASTM D 4491</td>
<td>0.7min.</td>
<td>0.7min.</td>
<td>0.7min.</td>
<td>0.7min.</td>
</tr>
</tbody>
</table>
4. The case of Dejen –Lumame road project

The project area is located in the northwestern area of the country, the Amhara National Regional State. The target road passes Gozamin-Wereda, Awabel-Wereda and Dejen-Wereda.

Figure 4.1 Map of route Dejen – Lumame road project
The project is the Rehabilitation which is being constructed with the assistance of the Japanese government by branch of Kajima construction. It is from Dejen to Lumame with a length of 29 km which started on 24 April 2014 and it is completed and opened for traffic.

4.1 Application Of geomembrane in road project

Geomembranes, thin-film geotextile composites, geosynthetic-clay liners, and field-coated geotextiles are used as fluid barriers to impede the flow of a liquid or gas from one location to another. This geosynthetic function has application in asphalt pavement overlays, encapsulation of swelling soils, and waste containment. Here the geomembrane acts as a stress relief layer. A protective cushion of nonwoven geotextiles is often used to prevent puncture of geomembranes (by reducing point stresses) from stones in the adjacent soil or drainage aggregate during installation and while in service.

In this project the contractor uses LDPE which is one type of Geomembrane as a countermeasure for areas which is highly black cotton soil.

The criterias to use geomembrane in in Dejen -Lumame road project

**Type of soil:** In Dejen –Lumame road project this LDPE is used effectively for black cotton stretches. The main reason were to separate this problematic soil from water ingress at list to the acceptable depth which varies according to the design. As a strategy the contractor applies the LDPE around the shoulder areas to the depth 1.5m -3m.

**Terrain type:** in this area the terrain of the road is flat to mountainous and this governs the depth of our geomembrane we should to apply. In the mountainous areas it should have to use the small depth or about 1.5m since the water drains to the lower elevation it doesn’t make like a ponds. Where as in the valley areas we should to insert the geomembrane in deep about 3m since the water goes in gravity to the lower elevation.

**Vertical curves of our road profiles:** this also determines the depth of our geomembrane to insert where the profile is in sag curve the depth of geomembrane as we go to the center of the sag curve the water also drains to the center therefore we should to care.

Where the vertical curves summit curve the depth of the geomembrane decreases when we goes to the center of the curve.

If it in flat area the depth of geomembrane is nearly equal since the water distributes the same and the probability of the water to have on the ground level is equal.
4.1.1 Geomembranes
Geomembranes are impermeable membranes that are used to line canals, pits, and ponds. They are also used in landfills to help prevent chemicals or other dangerous leachate from polluting surrounding areas. Essentially, geomembranes liner or barrier used with any geotechnical engineering related material so as to control fluid (or gas) migration in a human-made generally wherever liquid movement needs to be controlled. The range of applications, however, is great, and in addition to the environmental area, applications are rapidly growing in geotechnical, transportation, hydraulic, and private development engineering. There are different types of geomembrane of which LDPE is the most widely used in water proofing works.

4.1.1.1 Low Density Polyethylene waterproofing sheets (LDPE)
Low-Density Polyethylene (LDPE), the first of the polyethylene to be developed, is characterized by good toughness and flexibility, relatively low heat resistance, low-temperature impact resistance, and clarity in film form. Water is the major problem in most of the construction. To attack this problem we need to device some mechanism that could separate our structure from soil. This is achieved by using LDPE sheet placed in such a way that it prevents the passage of water in to the structure. It can be welded, or installed without welding using a heated weld & can be overlapped and sealed with adhesive tape.

Figure 4.2 Process of Application of LDPE in Dejen- Lumame road Project
4.2 Other alternatives soil stabilization in dejen lumame road project can be used.

1. Lime Stabilization:

- Modification occurs because calcium cations supplied by the hydrated lime replace the cations normally present on the surface of the clay mineral, promoted by the high pH environment of the lime-water system. Thus, the clay surface mineralogy is altered.
- These in return improves the strength, stiffness, durability and permeability, thus increasing load-bearing capacity of fine grained soils.
- Other benefits include reduction in plasticity, volume change and moisture holding characteristics.

Eventhough the above benefits and counter measure is applicable to dejen lumame road project it faces a lot of problems such as:

- Lime is not easily available.
- The cost of lime is expensive even when we compare to cement.
- It requires more advanced machinery during construction and the mobilization of machinery for a short length of project is costly.
- It needs Advanced professionals
- Thiny materials are emitted to the atmosphere and it is also another issue of
environmental pollution.

2. Cement stabilization:

- Cement and Lime can modify almost all fine-grained soils, but the most dramatic improvement occurs in clay soils of moderate to high plasticity.

- Factors which affect the strength and durability of soil-cement.
  - Soil type
  - Cement content
  - Aging and Curing condition (as curing period increase the strength increase)
  - Compaction condition (time elapsed b/n mixing & compaction has negative effect)

Stabilization of low plasticity and sandy soils usually require 5 to 14% cement by volume and less than 5% or cohesive materials.

Counter measure is applicable to dejen lumame road project it faces a lot of problems such as:

- The cost of cement is expensive.
- It requires more advanced machinery during construction and the mobilization of machinery for a short length of project is costly.
- It needs Advanced professionals
- Thiny materials are emitted to the atmosphere and it is also another issue of environmental pollution.
- For a short length of the stretch it is not applicable.

Finally the cost calculation for cement stabilization is as follows:

Is needs about 5% of cement and 10% of sand per total volume of the soil in our profile.

It is recommended to be safe to mix the cement sand and black cotton soil to a depth of 1 meter. If we take 5 meter of length of the road the volume will be as follows.

Total volume = length * width * depth

= 5m * 14m * 1m

= 70m³

Volume of sand = 10% (70)

= 7m³
The current market of sand per $1m^3$ is 440 birr.
The total cost = $7m^3 \times 440\text{birr/m}^3$

= $3080\text{birr}$

Volume of cement = $5\% (70m^3)$

= $3.5m^3$

Volume of cement = $10\% (70)$

= $7m^3$

The current market of cement per qtls is 230 birr.

One qtl of cement = $2 \times$ box size

One qtl of cement = $2 \times 0.2 \times 0.4 \times 0.6$

= $0.096 m^3$ its cost is 230birr

The total cost = $(3.5/0.096)m^3 \times 230\text{birr/m}^3$

= $8385.40\text{birr}$ per 5 meter of the road

Total cost without machinery = $8385.40 + 3080 = 11,465.40\text{birr}$ to construct the 5 meter length of road.

To compare using geomembrane if we take to use geo membrane in both side of our road for a length of 5 meterlets calculate the total cost.

Total area of geo membrane = length $\times$ depth $\times$ 2sides $\times$ double bonded

= $5m \times 5m \times 2 \times 2$

= $100 m^2$

The unit price of geo membrane = $34.38$ birr.

Total cost for 5 meter length of road = $34.38 \times 100 = 3438$ birr which is much lower than using cement stabilization note that it is with only the matrial but if we include the machinery it is too costly.

3. Using selected material: Replacement of the black cotton soil by selected material is another option but it is bulky volume to cut and backfill again since the depth of the black cotton soil is too deep (greater than 3m). And to show the cost effectiveness I have calculated in below counter measures type B, C and C'.
The counter measure carried out to treat the black cotton soil is in four type of counter measures depending on the existing conditions these are:

i. Type A: since the existing road is on the town there is no water engross from the side so we donot use ang geomembrane treatment dueto zero water ingerss from the side of our asphalt.

![](image)

Figure 4.4 cross section of road type A

ii. Type B: in one side of the new road is the existing threfore thegeomembrane have carried only in one side.
Cost computation of type B

The LDPE used from 2+000 - 2+350 is type B mean the one side of our road have LDPE geomembrane with a thickness of 2.5mm and it is double bounded having a thickness of 5mm in a depth of 2m while in the other side is existing road and we don’t use LDPE geomembrane.

Total area of LDPE in one side = 350m*(2m+2m)*2

= 2800 m²

The unit price of LDPE per square meter is 34.38 Ethiopian birr.

Total cost = 2800 m² * 34.38 Ethiopian birr/ m²

= 96,264 birr.

The total volume of the soil that was to be removed and backfill is deducted due to using the LDPE.

Total volume of soil to be removed was = length * width * depth

= 350m * 14m * 1m = 4,900 m³

The unit rate to remove the waste material is 37 birr/ m³.km. and the material was remove with in

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Project for the partial fulfillment of Masters of Engineering

26
near site about 1km. therefore;

Total cost to remove the black cotton soil = 4,900m$^3$(37 birr/ m$^3$km) = 181,300 birr.

The total volume of selected material to fill will be the same volume of removed = 4,900m$^3$.

The unit rate of selected material is 67 birr/ m$^3$km. and the borrow material was near site about 1km. therefore;

The total cost of selected material = 4,900m$^3$ (67 birr/ m$^3$km) = 328,300 birr.

Then let's compare the total cost using geomembrane and without using geomembrane.

- Using geomembrane the total cost = 96,264 birr.
- Without Using geomembrane the total cost = Total volume of soil to be removed + The total cost of selected material to be used.

Without geomembrane the total cost = 181,300 birr + 328,300 birr = 509,600 birr.

Total cost saved due using the geomembrane = the total cost Without geomembrane - the total cost using geomembrane.

Total cost saved due using the geomembrane = 509,600 birr - 96,264 birr = 413,336 birr.

This can build another additional of 1503 m of similar type of our road using geotextile.

iii. Type C: the double layer of LDPE is carried out in both side.

Figure 4.6 cross section of road type C
Cost computation of type c

The LDPE used from 1+150 - 1+365 is type C means in both sides there is a LDPE geomembrane with a thickness of 2.5mm and it is double bounded having a thickness of 5mm. in a depth of 3m.

Total area of LDPE in one side = 215m*(3m+2m)*2

=2150m².

In both side a total of =2150m² (2) =4300 m².

The unit price of LDPE per square meter is 34.38 Ethiopian birr.

Total cost=4300 m²*34.38 Ethiopian birr/ m²

= 147,834 birr.

The total volume of the soil that was to be removed and backfill is deducted due to using the LDPE.

Total volume of soil to be removed was=length*width*depth

=215m*14m*2m

=6,020m³

The unit rate to remove the waste material is 37 birr/ m³km. and the material was remove with in near site about 1km.therefore;

Total cost to remove the black cotton soil = 6,020m³ (37 birr/ m³km) = 222,740 birr.

The total volume of selected material to fill will be the same volumeof removed=6,020m³.

The unit rate of selected material is 67 birr/ m³km. and the borrow material was near site about 1km.therefore;

The total cost of selected material = 6,020m³ (67 birr/ m³km)=403,340 birr.

Then lets compare the total cost using geomembrane and without using geomembrane.

- Using geomembrane the total cost=147,834 birr.
- Using with out geomembrane the total cost= Total volume of soil to be removed + The total cost of selected material to be used .
  Without geomembrane the total cost=222,740 birr + 403,340 birr
  =626,080 birr.

Total cost saved due using the geomembrane = the total cost Without geomembrane - the total
cost using geomembrane.

Total cost saved due using the geomembrane=626,080 birr - 147,834 birr

=478,246birr.

This can built another additional of 695m type C of our road using geotextile.

iv. **Type c’** : the existin road was in the center of the new road that’s why it need treatment of LDPE in both side.

Figure 4.7 cross section of road Type c’

**Cost computation of type c’**

The LDPE used from 0+150-0+650 is type C’ mean in both sides there is a LDPE geomembrane with a thickness of 2.5mm and it is double bounded having a thickness of 5mm. in a depth of 2.5m.

Total area of LDPE in one side = 500m*(2.5m+2m)*2

=4500m².

In both side a total of =4500m²*2(2) =9000 m².

The unit price of LDPE per square meter is 34.38 Ethiopian birr.

Total cost=9000 m² *34.38 Ethiopian birr/ m²
= 309,420 birr.

The total volume of the soil that was to be removed and backfill is deducted due to using the LDPE.

Total volume of soil to be removed was = length * width * depth

= 500m * 14m * 1.5m = 10,500m³

The unit rate to remove the waste material is 37 birr/m³ km. and the material was removed within near site about 1km. therefore;

Total cost to remove the black cotton soil = 10,500m³ * (37 birr/m³ km) = 388,500 birr.

The total volume of selected material to fill will be the same volume of removed = 10,500m³.

The unit rate of selected material is 67 birr/m³ km. and the borrow material was near site about 1km. therefore;

The total cost of selected material = 10,500m³ * (67 birr/m³ km) = 703,500 birr.

Then let's compare the total cost using geomembrane and without using geomembrane.

Using geomembrane the total cost = 309,420 birr.

Using without geomembrane the total cost = Total volume of soil to be removed + The total cost of selected material to be used.

Without geomembrane the total cost = 388,500 birr + 703,500 birr = 1,092,000 birr.

Total cost saved due using the geomembrane = the total cost Without geomembrane - the total cost using geomembrane.

Total cost saved due using the geomembrane = 1,092,000 birr - 309,420 birr = 782,580 birr.

This can built another additional of 1265m of our road using geotextile.
5. Conclusion
From my Literature review and case study i can conclude that textile is versatile material in road pavement protection. It can be used as separation, filtration, and drainage and reinforcing. Using geo synthetic in the problematic soil (soils with high swell and shrinkage) we can protect failures of pavement inroad and other civil works. In my case study (Dejen-Lumame road project) the application of geosynthetics was LDPE which is one type of geomembrane as water shielding purpose. The main aim is to separate problematic soils (black cotton soil) to the acceptable depth from water ingress. To do this effectively the JAICA uses LDPE water proofing sheet as counter measure. LDPE is polyethylene material used for protection of water ingress into the sub grade soil and pavement structure. This material is impermeable material and used as vertical and partial barrier in three type based on the condition of road as in the above mentioned. LDPE is a type of geomembrane and can be used as horizontal and vertical barriers for road projects. It has temperature resistance capacity 80 to $95^0c$. 

6. Recommendations

Now a day’s Application of geosynthetic in civil engineering projects become Indispensable. As a result different characteristics of soil and rock properties are improved very much. The following are our recommendation for concerned bodies.

❖ Further study should be done so as to prepare manuals/ guides that can meet our civil engineering problems related to our country’s geological profile.

❖ ERA should initiate the application of geosynthesis where it is necessary.
❖ In using Geotextile care must be taken from the stage of production to installation
❖ In selecting geosynthesis care must be taken in selecting the required geosynthesis to the problem we face.
❖ While using geotextiles in filtration purpose care must be given to protect clogging of opening, to do this materials with filter capacity (sand) must be used
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