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Comparative study of Normal Pavement and Geosynthetic Fabric Pavement

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ABSTRACT

With the constant damage on the roads and heavy maintenance cost the comparative study of normal pavement along with the Geosynthetic pavement is necessary. Mainly the roads are classified as rigid pavement and Flexible pavement. The Normal Highways Fall in the category of Flexible Pavements. With the advent of new researches and new technologies in Highway pavement the Flexible pavement came into existence. The Geosynthetic pavement fall in Flexible pavement category. The Aim of Using the Goesynthetic pavement is to increase the technical properties of the Highway pavements. Geosynthetic is also used as fluid barrier, reinforcement agent and strain absorbing. The study regarding the use of Geosynthetic for the betterment of the road properties have been done previously. The use of geosynthetic fibres are also done. The need of this study is to know about the types of pavements and nature of Geosynthetic paving fabrics against the dynamic loading of the vehicles, and continuous wear and tear of the topmost bituminous layer on roads. With the help of this study we can understand the dynamic nature of roads and application of Geosynthetic in the pavement. The geosynthetic paving fabric proves to be economical, and have comparatively less maintenance then the rigid roads. The life of the roads can be increased by the use of Geosynthetic paving fabric. This study indicates that the Geosynthetic paving fabric proves to be more durable, economical and effective for Highway pavements. It has a large range of application for the development of Highways, Expressways etc.

Key words: Pavement types, Geo-synthetic Material, Geogrid, Flexible pavement design, Thickness reduction, Strength Increase, Material saving.

CHAPTER 1. INTRODUCTION

1.1 General Introduction

Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load imposed upon it. Pavement transfers the traffic load from the upper surface to the natural soil and grants friction for the vehicles thus providing comfort to the drivers. Major concern for Pavement design are Strom water drainage and environmental conditions.

A pavement is a structure made of multiple layers of processed materials above the natural soil sub-base, whose chief function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favourable light reflecting characteristics, and low noise pollution.

The main aim is to ascertain that the stresses transmitted due to wheel load are reasonably low, so that they will not exceed bearing capacity of the sub-grade. The roads are mainly classified as below:

1.1.1 RIGID PAVEMENT

The characteristic of rigid pavement are associated with Rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil. These pavement is laid in slabs with steel reinforcement. The Rigid Pavement are the pavements which does not pass the vehicle's axle load to the subgrade and does not reflect the deformation to the subgrade. As the load is not transferred to the base or sub-base layers so the cracks may be developed which results into rupture of the top most concrete layer of the pavement.

The load is distributed over small area and up to sub-base layer only from the concrete layer. The rigid pavements are made of cement concrete either plain, reinforced or prestressed concrete. Maximum flexural stress occurs in the slab due to wheel load and the temperature changes which are the critical condition of stress in the rigid pavement. Rigid pavement is designed and analysed by using the Elastic theory.

1.1.2 FLEXIBLE PAVEMENT

An ideal flexible pavement system is made up of four main layers: asphalt concrete, base course, sub-base, and subgrade. The top most surface layer is made of asphalt concrete, which is a bituminous hot-mix aggregate extracted from distillation of crude petroleum. The asphalt concrete is underlain by a layer of base course, typically consisting of 0.2 m to 0.3 m of unbound coarse aggregate.

Flexible pavement are those pavements which transfers the distortion of base and the subsequent layers to the surface. In Flexible pavement primarily asphalt, is laid without reinforcement or with a specialized fabric reinforcement that permits minimum flow or repositioning of the roadbed underground changes.

The flexible pavement design is based on load distributing characteristic to the underneath component layers. As a whole negligible flexural strength is observed during structural action of the roads in Flexible pavement. Under the wheel load the maximum compressive stress is observed which is equal to contact pressure under the wheels. The stresses get decreased in the lower layer due to the ability of distributing the stress over large area in the inverted cone shape.

1.2 What is Geosynthetics?

Geosynthetics are synthetic products used to stabilize terrain. Various civil engineering problems can be solved by these polymeric products i.e. Geo-synthetic.

The polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. They can also be used in exposed applications.

Geosynthetics are available in a variety of types and materials. Three most important usages of geosynthetics are fluid barrier, strain absorbing, and reinforcement agent in pavement.

Geosynthetic is a planar product manufactured from a various synthetic polymer materials that are specifically fabricated to be used in geotechnical, geo-environmental, hydraulic and transportation engineering related materials as an integral part of a man-made project, structure, or system.

The Geosynthetic may be classified as: Geotextiles, Geogrids, Geonets, Geo-membrane, Geosynthetic clay liners, Geo-foam.

The main application of geosynthetic are:

1. In roads and pavement
2. In subsurface drainage
3. In erosion and sediment control
4. In reinforcement soil control

There are 4 main applications for geosynthetic Grids in road and pavement are:

1. Subgrade separation and stabilization,
2. Base Reinforcement,
3. Overlay stress absorption,
4. Overlay Reinforcement.

Geosynthetic materials are commonly used to provide reinforcement to the granular unbound layer.

Table 1: Alaska's specifications for geo-grid used in granular layers.

Alaska's specifications for geogrid used in granular layers. **Property**	**Requirement**	**Test Method**
Average Aperture Size, MD1 XD2	0.8-2.0 in 0.8-2.0 in	ID Callipered Maximum Inside Dimension
Open Area, min	70%3	Corps of Engineers CW-02215
Weight, min	5.5 oz./yd.	ASTM D 3776
Rib Thickness, min	30 mils	ASTM D 1777
Junction Thickness, min	60 mils	
Tensile Strength, Wide Width Strip, min At 2% Strain At 5% Strain At 15% Strain or Ultimate	275 lb./ft. 550 lb. /ft. 800lb. /ft.	ASTM D 4595
Flexural Rigidity, min	25,000 mg-cm	ASTM D 1388
Junction Strength, min	80%	ASTM D 638 Mod4

The reinforcement may be provided in the form of either a geotextile fabric or a geo-grid material. The reinforcing fabric is usually manufactured from polyester, polypropylene or polypropylene-nylon material.

1.3 Road grid

Road grid are particularly knitted fiberglass grid ideal for asphalt reinforcement. Bituminous material are overlaid on these grids, for proper adhesion to asphalt layers. The bonding between road grids ensures its position to accept the tensile stresses and to distribute them. Road grid ensures the peel and stick feature and remove the need of track coat and also ensures quick installation. Due to excellent beat resistance property these material is recommended for minimal shrinkage at high temperature of 200°c and optimal elastic modules.

It may be noted that Road grids are produces with aperture size 25 X 25 mm. This aperture size is based upon the average asphalt particles size available for obtaining the best results. This is the optimal aperture size to ensure the best bonding between the asphalt layers.

The main function of Geogrids are as below:

In Base and Subgrade layers, Over Hot mix asphalt Layers, over unbound materials, for bound materials.

The one of the function of geogrids under over unbound materials is prefabricated Drainage Layer is explained as under.

1.3.1 Prefabricated Drainage Layer

Another geosynthetic application in unbound materials is that of a prefabricated drainage layer. The geosynthetic layer provides for lateral drainage in a pavement system, and may also provide other characteristics such as separation and stress absorption.

Table 3: South Dakota's specifications for various applications of geo-synthetics in unbound materials.

GEOTEXTILE FABRIC TYPE										
Geotextile Property	**Test Method**	**Separation2**		**Drains**				**Riprap**	**Reinforcement**	
		S1	S2	D1	D2	D33	D43	RR	R1	R24
Grab Tensile Strength1, lbs., min	ASTM D-4632	180	180	180	80	100	N/A	200	N/A	-
Grab Tensile Elongation, %, min	ASTM D-4632	N/A	N/A	N/A	N/A	N/A	N/A	15	N/A	-
Grab Tensile Strength1, lbs./in, min Wide-Width Method	ASTM D-4595	N/A	N/A	N/A	N/A	N/A	N/A	N/A	270	-
Grab Tensile Elongation, % max	ASTM D-4595	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	-
Trapezoid Tear Strength, lbs., min (any direction)	ASTM D-4533	50	50	50	25	N/A	N/A	50	100	-
Puncture Strength lbs., min	ASTM D-4833	75	75	80	25	N/A	N/A	80	100	-
AOS < mm (> US STD Sieve)	ASTM D-4491	0.212 (70)	0.150 (100)	0.300 (50)	0.150 (100)	0.125-0.425 (40-120)	0.125-0.425 (40-120)	0.300 (50)	0.600 (30)	-
Permittivity, sec-1, min	ASTM D-4491	0.10	0.05	0.50	.05	0.70	1.0 relaxed	0.20	0.05	-
UV Resistance (after 150 hrs.) % Strength Retained	ASTM D-4355	70	70	70	70	70	N/A	70	70	-
Weight oz./sy	N/A	N/A	N/A	N/A	N/A	3.5	N/A	N/A	-	
Sewn-Seam Strength, lbs.	ASTM D-4632	160	160	160	70	90	N/A	180	N/A	-
Sewn-Seam Strength, lbs./in	ASTM D-4884	N/A	N/A	N/A	N/A	N/A	N/A	N/A	240	-

1.4 Tensile Test on Geogrid and its results.

The tensile test of geogrid is carried out as per the Indian Standards. The results and graph are as below showing the Load v/s Rib tensile strength in machine direction and Load v/s Elongation of geogrid.

1.4.1 Results of the Tensile test of Geogrids are as follows:

LOAD (kN)	SINGLE RIB TENSILE STRENGTH (kN/m) (MD)
30	40.21
60	74.4
80	93.56
100	125.0
200	218.4

Table 5: Load v/s Rib Tensile strength in Machine Direction(MD) of geogrid.

1. Graph of Load v/s Rib Tensile Strength

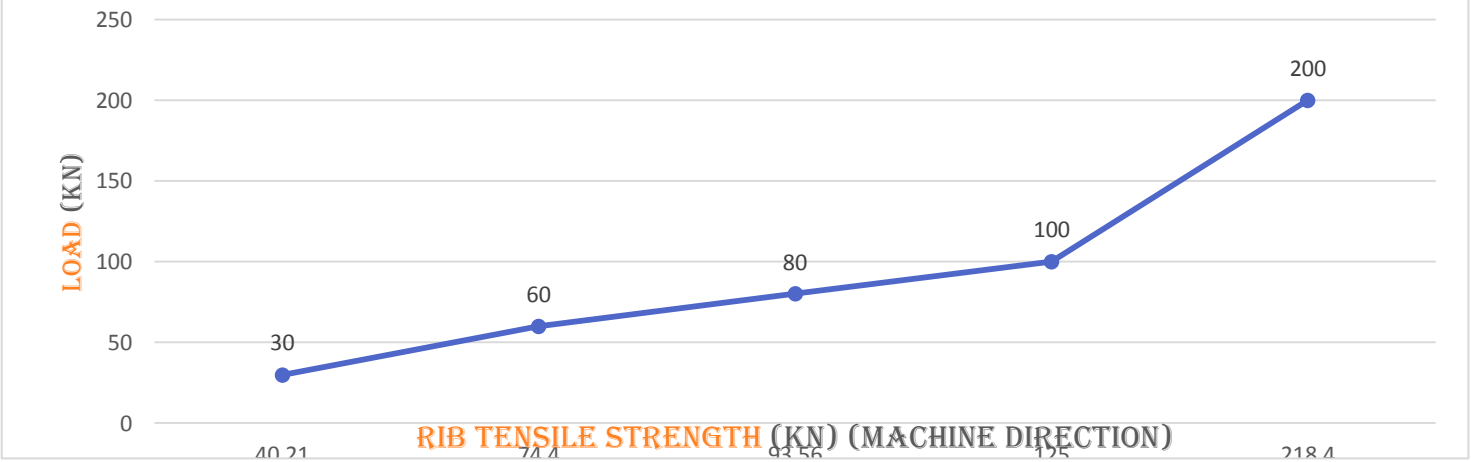
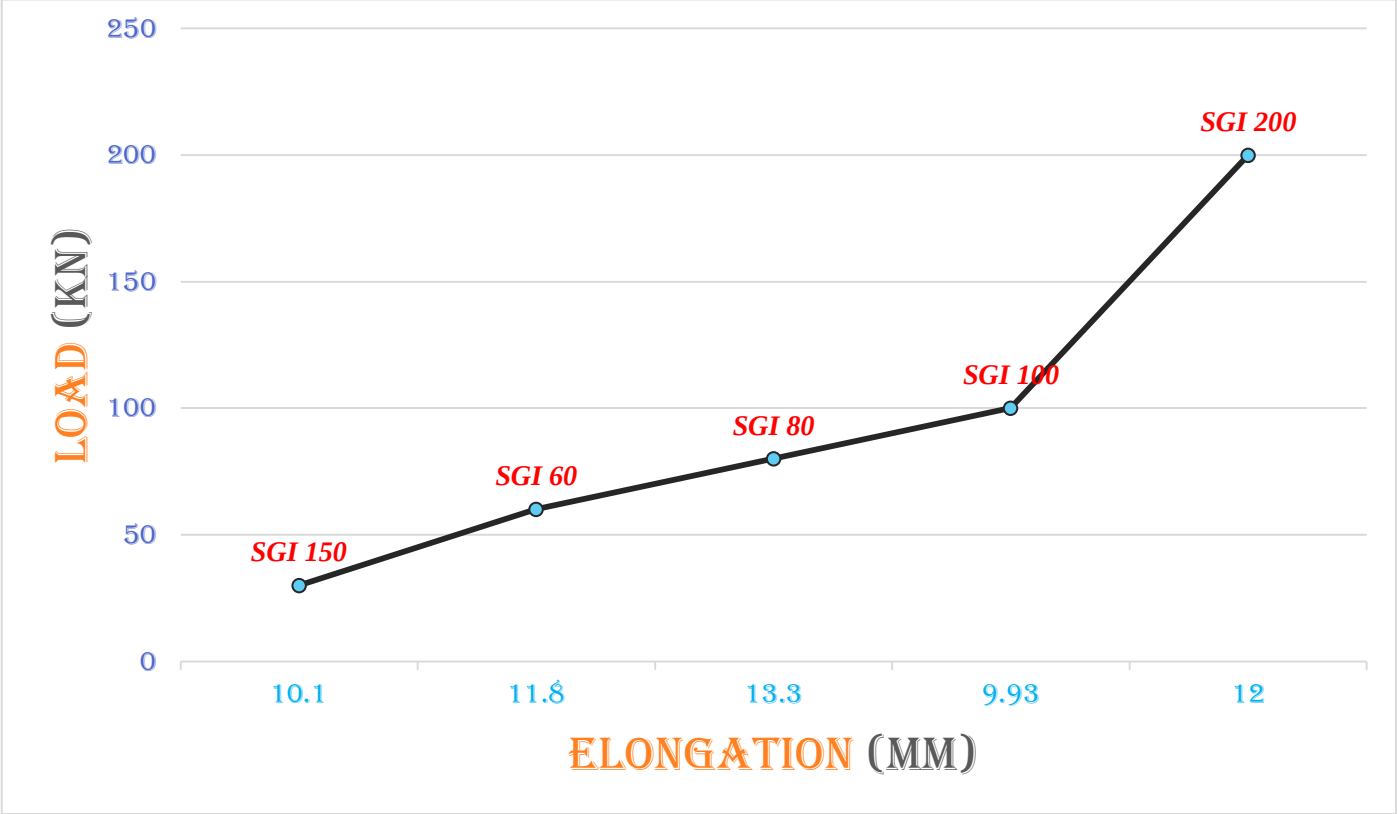


Table 6: Load v/s Elongation of Geo grid

LOAD (kN)	ELONGATION (mm)
30	10.1
60	11.8
80	13.3

100	**9.939**
200	**12.0**

2. Graph of Load v/s Elongation



1.5 Design of Flexible Pavement:

Data Collected: 1. Traffic Survey

2. Soil Survey

1.5.1 Traffic Survey

Traffic Survey is a survey which is done to calculate the number of vehicles passing over it, type of vehicles, loads acting over it.

The vehicles can be divided according to the type of the axles used in it.

They are enumerated as: **Two wheelers,**
Four wheelers,
Single Axles,
Double Axles,
Multi Axles.

Now the Traffic survey includes the computation of the number of vehicles i.e. Million Standard Axles (msa).

Table:7 Computation of Million Standard Axles.

Sr. No.	Vehicle type	Near Ghaduli (direction Santalpur tokhavda)	Near khavda (direction khavda to Santalpur)	PCU factor	Near Ghaduli (direction Santalpur to khavda)	Near khavda (direction khavda to Santalpur)	Total No. of vehicle	Total No. of PCU
1	2wheelers	378	323	.5	183	162	351	176
2	Passenger car	2478	2232	1	2478	2232	4710	4710
3	Mini bus	153	93	2	306	186	492	984
4	Standard bus	851	365	3	2553	1095	3648	10942
5	LCV	481	206	1.5	722	309	1031	1547
6	2-Axle	2419	1037	3	7257	3111	10368	31104
7	3-Axle	283	121	4.5	1274	545	1819	8186
8	MAV	272	31	6	432	186	618	3108
9	Ag.Tr.without Trailor	151	56	1.5	227	84	311	466
10	Ag.Tr.with Trailor	101	26	2	202	52	254	508
TOTAL		**7367**	**4490**		**15640**	**7962**	**23602**	**62033**

Sr. no	Type of vehicle	Number of vehicle	VDF	Standard Axle per CV
1	Standard bus	**1216**	**0.91**	**1108**
2	LCV	**687**	**1.1**	**756**
3	2-Axle	**3456**	**3**	**10368**
4	3-Axle	**404**	**3**	**1212**
5	MAV	**103**	**2.95**	**304**
	Total	**5866**		**13748**

Table 8: Standard Axle per CV

1.5.2 Soil Survey

Soil survey includes computation of the soil bearing capacity of the soil on which the road pavement rest. The California Bearing Ratio (CBR) of the soil for the pavement must be greater than 3 i.e. (>3).

The CBR value of the soil near Shantalpur to Khavda is as follows:

Table 9(a): CBR Value of Soil for every KM

Sr. no. Survey for every Km	Modified Proctor Density		CBR Value (Soaked Condition)%
	Maximum Dry Density in gm./cc	Optimum Moisture Content in %	
1.	1.762	12.9	5.5
2.	1.777	13.5	5.6
3.	1.765	13.6	5.1
4.	1.759	13.2	5.3
5.	1.771	13.7	5.2
6.	1.768	13.9	5.5
7.	1.758	13.8	5.1
8.	1.769	13.5	5.3
9.	1.772	13.7	5.5
10.	1.758	13.2	5.8
11.	1.769	13.5	5.6
12.	1.772	13.2	5.2
13.	1.784	13.9	5.5
14.	1.778	13.2	5.4
15.	1.769	13.4	5.2
16.	1.784	13.6	5.6
17.	1.773	13.2	5.1
18.	1.766	13.8	5.4
19.	1.772	13.5	5.3
20.	1.745	13.1	5.5

8.1 Limitation

- The initial cost is high.
- There is possibility of the wrong design of the pavement with less knowledge.

8.2 Future Enhancement

- Design of the pavement according to the requirement and the loads over it.
- Method of applying Geogrid over the roads.
- Materials used in Geogrid.

8.3 Conclusion

We have completed our project work based on Highway engineering and Pavement Design. The work we have done in this project is how we have reduced the thickness of the pavement layers with the use of the Geogrid polymeric materials. With the use of the Geogrid materials the maintenance cost is reduced and the life of the roads were increased.