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Unconventional and Simplified Approach towards Unpaved Roads: Application of Geosynthetics

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Abstract: A field trial was carried out to investigate the performance of different unconventional geosynthetic materials in unpaved road construction over soft ground.The test site comprises of 25 m long, by 3 m wide test sections, built on a subgrade of undrained shear strength approximately 45 kPa . One isunreinforced and serves as a control section in the study, three sections includea geotextile, and one includes a geogrid. Each test section incorporated avariable thickness of sandy gravel base course material, between25 and 45 cmthick. They were loaded in sequence by a vehicle of standard axle load.Performance of the test sections was evaluated from measurements of rut depth, base course thickness, base course deformations, geosynthetic strain, and deformed profile of the geosynthetic, with increasing number of vehicle passes.The four geosynthetic materials used exhibited a broad range of stiffness and material properties ,but the general performance of the four reinforced sections was similar on the base course layers. On contrary thinner subgrades showed a significant difference between the geosynthetics
Keywords: Geo-synthetic materials, geo-textile, geo-grid, unpaved road.

I. INTRODUCTION

Geosynthetic materials have gained much popularity in the last few decades due to its wide range of engineering applications. Geology are synthetic materials made of polymers. Polymeric materials are made of individual individual monomers. Homo polymers are the most common type of monomers are used in the manufacture of geology. Geosynthetic materials are made and do not rot. It continues to classify into various categories such as geo cloth, geo membrane, geogrids, geonet and geo composites. Scope of this investigation is confined to geogrids and geo fabrics.

A. Geogrid

Geogrids are made from polymer with a high modulus. The polymeric materials used to make geogrids are high density polyethylene and polyster or polypropyelene with high coherence and toughness.. Sheets made from extrusion are rolled or dragged in one or more perpendicular directions under controlled strain rates and temperatures whuch depends on the styles preffered. Geo textiles are available in both ‘uni axial’ and ‘bi axial’ styles which depends after being perforated, on how the high gauge polymer sheets are drawn.

B. Geotextiles

Geotextiles are oldest type of geosynthetics. The two most common materials are polypropylene and polyester. Main materials used in the manufacture of geotextiles. These fibres are turned into a geotextile throughout the manufacturing process. planar permeable A fabric is a type of structure. Fabrics that are most commonly used for geotextiles There are two types of fabrics: woven and nonwoven. Knitted materials are also available, but they are more expensive are In the geotextile sector, this term is rarely used.. The manufacture of non woven geotextiles is complicated than that of woven geotextiles.

C. Applications and functions of geosynthetics

There are various uses of geo-materials in public engineering. With new technology geo-products these days are becoming increasingly popular and is very important in various engineering programs. It is very possible continuing to diversify the use of public geo materials engineering. The main functions of geo-materials may be classified into following groups:

1) *Separation:* Geographical materials often have more than one function when used civil engineering. Satisfy one job and apply to roof construction and. In road construction they separate the different layers as well which is why you have blocked the mixing process, with the benefit of working as a reinforcement .

2) *Strengthening:* Geosynthetic materials nowadays are used in a variety of temporary and permanent forms earth structures such as retaining walls, foundations and installation. The concept of using geometric materials has proven to be very expensive and easy solution to various problems related to temporary and permanent residence .properties.
3) *Filtering:* Proper geosynthetic materials have the ability to provide fine pipes roads and other structures that require adequate water capacity. Geosynthetic materials not only provide water marks but and it can add power to a building at the same time.

II. LITERATURE REVIEW

For quite some time now, geogrids and geotextiles have previously proven to be effective in the building of a variety of unpaved roads on soft soil. In their applications on unpaved roads, geotextiles frequently perform more than one of the essential tasks of separation, strengthening, filtration, and drainage. Geogrids, on the other hand, are mostly used as reinforcement and, in some situations, as dividers. During the last few decades, a significant amount of geosynthetic reinforcement of multilayer soil systems has been the subject of investigation and it was completed.

A. Fundamentals of Design Approach

Various design procedures use a similar approach, assumptions about vehicle traffic, bearing capacity, anchoring impact, and stabilising mechanism, notably the relative relevance of a tension membrane effect, differ. Some of geosynthetic-soil interactions are:
1) Membrane effect
2) Effect of anchorage

B. Field study

There have been few well-controlled field trials to investigate the impact of geosynthetics on unpaved roads. The U.S. Army Waterways Experiment Station's early work is cited extensively in more contemporary design methodologies (Webbstar and Watkuna, 1979; Webbstar and Kalfor, 1979). Webster and Watkins (1977) describe ‘field research’ that included 7 test sections: 1 non-woven spun yarn reinforcement polyester needle punched bonded geotextile, 1 reinforced by a neoprene-coated one-ply woven nylon membrane, as a control portion, one was left unreinforced.. Other materials than geosynthetics were used to strengthen the remaining portions.

C. Design procedures

Over the last two decades, several design methodologies for unpaved roads utilising geosynthetics have been developed. Many were created for specific commercial products, while others were created to be generic. They can be categorised into three major categories: empirical, semi-theoretical, and theoretical., 3rd study is simply analytical and incorporates tangible element, and it uses field experience and experimental data in conjunction with accessible theory.

There are few empirical design methodologies in previous studies, just ‘one’ that is framed as ‘strictly empirical’ has been discovered during that reviewThis method was created by Jaecklin (1986) utilising a detailed research on basis of previous works. They consider traffic,depth of rut, strength of subgrade, and qualities of the base course and thickness, as well as a geotextile factor that is based on the fabric's mobilised strain.

A combination of field experience, experimental data, and theory is unquestionably the most sensible basis for a design technique. Many semi-theoretical design approaches are there, however they vary, as well as the extent to which different design aspects are examined and the findings interpreted.

Bender and Barenberg (1975) and Barenberg et al. (1975) (1978) established a simple design approach for a nonwoven geotextile reinforced aggregate subgrade system , depending on various tests .

According to their findings, failure occurred in ‘unreinforced system’ when the stress applied to ‘un drained’ shear strength of ‘subgrade soil’ was about (3. 3) in system that is not reinforced and around six in ‘reinforced system’. For ‘local' and ‘general' shear failures, these results match Terzaghi's bearing capacity characteristics.. The vertical stress is computed by use of ‘Boussinesq theory’ when geotextile is employed. to estimate base course thickness, with allowable stress on subgrade not exceeding 6 times the ‘undrained shear strength’ of subgrade.. Identical approach applied with the unreinforced system, thus ‘bearing capacity factor’ of ‘3.3’ besides using 6. Mirafe 140, employed in hus research programme, that caution should be exercised when extrapolating the findings to other fabrics.

III.SITE FEATURES AND EXPERIMENTAL METHODOLOGY

The study was undertaken in the Kangan area of Jammu and Kashmir. Kangan is a town in Jammu and Kashmir's Ganderbal district. It is a tehsil in the Ganderbal District. It is located on the Nallah Sindh River and spans a 50-kilometer-long canyon valley.It is surrounded by places like Sonamarg and Naranag. Kangan is located at 34.263°N 74.903°E. It has an average elevation of 1,810 metres (5,940 ft) above mean sea level. The Sind Valley was formed over thousands of years as the Sind River carved its way through the Himalayan highlands. The valley's glaciers are thinning. The river continues to throw sand sheets in Ganderbal's lower sections today. At numerous locations, gradual erosive processes have washed away side forests and produced a deep valley.. The area's bedrock geology has changed over millions of years, and the unconsolidated Quaternary sediments have only been in place for a few thousand years.

A. Properties of soil

The final test site was chosen to provide a generally homogeneous near-field environment. Surface strata along a proposed 25-meter-long unpaved road test segment 3 m in width. A total of five test pits, ranging in depth from 0.5 to 1.8 metres, were dug. Five field vane tests were carried out. The test pits and sampling stations are located at the Figure 1 depicts the ultimate site .The stratigraphy of a location is described using the 9 test pits were examined, 6 of whom were not deep and were used to find groundwater table and determine the depth to the soft subgrade The second and third are more in-depth and provide more information.A somewhat silty clay and a blackish-brown soil lie beneath the vegetated topsoil,brown, which had some strata variation across surface. Each test yielded specific gravity measurements from two distinct depths.

B. Shear strength characteristics by vane shear method

The vane field test was performed at a distance of 0.3 m. On soft ground, no borehole is required. The drawback of ‘vane test’ confined has no surety, about rods that undergo punching through soil strata with no buckling. Use of vanes were of length ‘13’ cm and of width ‘6.5’ cm and of height ‘17.2’ cm and of width ‘8’ cm . vane contain a torque utility tool, supported by a portable frame. ‘vane tests’ enlisted are expressed in Figure ‘3.9’. Opaque line expressed in numbers represents normal value in every test. Power performa in depth is almost the same, and in between 30 and 40 kPa.

C. Specification of material

Well-graded, angular gravel with sand is regarded as the base coarse material utilised in road building. A good quality base course material that would improve the pavement's performance was considered. Aggregate base was traditionally manufactured by combining different sizes of crushed rock to form aggregate with particular desirable qualities.. aggregate of 20 mm Base is an aggregate made of a precise formula of various sizes and grade of rock ranging from 20 mm to fine dust that is utilised and desired in roadways. Table 1, 2 and 3 demonstrate the properties of the nonwoven geotextiles, woven geo textiles, and geogrids utilised in the field trial, respectively. These figures are based on average value provided by the manufacturers. Regrettably, there is no standardisation on how things should be done. Because the qualities of geosynthetics are reported, comparing the properties of geosynthetics from different manufacturers might be difficult.

D. Arrangement of test section

To make traffic loading easier, the five exam portions were placed in order. The configuration was chosen to work around the site's limits and to make construction easier..Each test segment measures 3 metres broad by 5 metres long. Base course thickness has crucial impact on road's qualities, as test findings later verified. The base course's thickness was observed from minimal with '25’ cm and maximal with '50’ cm are required.

E. Loading vehicle

Single axle, two tyre vehicle of axle load 8800 kg, tyre (inflation pressure) with ‘620’ kPa was utilised to traffic the test sections. Figure depicts the layout of the test vehicle's wheel spacing and axle load. With average speed ‘10’ km/hour, vehicle were made to move forward and backward thereafter across full length of the track. To track traffic, the number of typical axle load passes was employed. The test vehicle's front single-axle, single wheels have minor effects on road performance and were so omitted when reporting the number of load passes.

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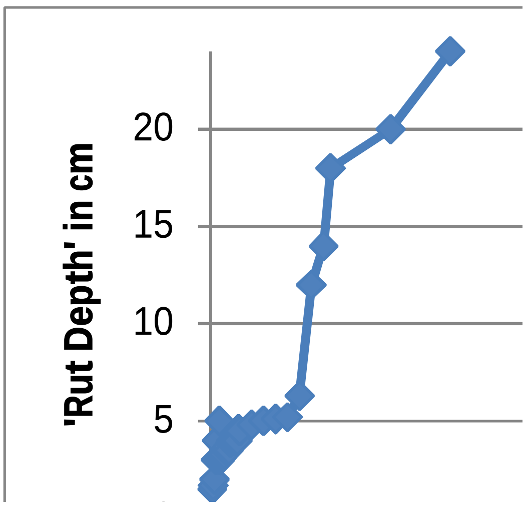
IV. ANALYSIS OF TEST RESULTS AND DISCUSSION

A. Rut Development.

During this time, loading vehicle made a total of 400 passes. In the early phases of traffic loading, only some passes a day were taken, and calculations recorded frequently to increase an improved indulgent of ‘soil aggregate system’(reinforced) behavior also to detect primary drift of ‘base course’ and ‘sub grade’ deformations. .Field trial was postponed until the second week of February following ‘8’ passes over next date of ‘passage loading’. For first 24 runs, rut dimensions was taken past each vehicle pass over every test segments, and after every second pass in other cross-sections. Then, up to 100 passes, measurements were collected generally every 10 passes in all cross-sections, and every 20 passes beyond that. . For thicker sections, the difference in rut depth between reinforced and unreinforced areas is less noticeable. The behavior is identical through overall ‘test sections’ of almost ’50 cm’of layers. The graphical representation of ‘depth of ruts’ for a base course thickness of ‘25’cm is shown through graphs.



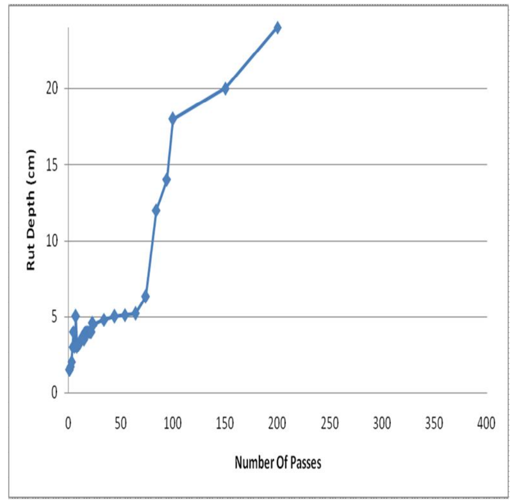
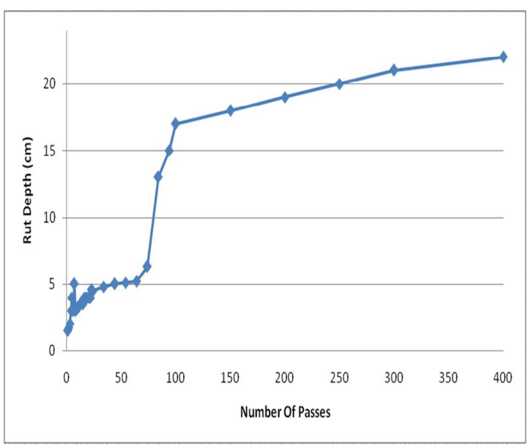


Figure 1‘Rut depth’vs number of ‘passes’ (Unreinforced Section)

Figure 2 Rut depth vs number of passes on woven geo textile Section



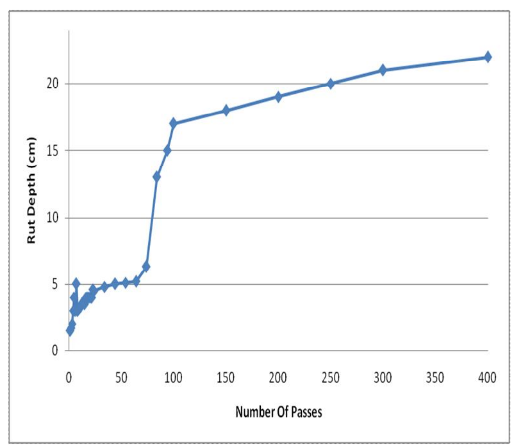


Figure 3 Rut depth vs number of passes on non woven geo textile Section

Figure 4 Rut depth vs number of passes of geo grid Section

B. Subgrade Settlement

At various points during the trial, deformations of the subgrade surface were recorded by digging a trench down to the geosynthetics' surface and measuring vertical displacement against a horizontal refrence. To minimise system disruption, most of the trenches employed on almost half of the full width of the road. They were approximately 30 centimetres broad., They were backfilled, compacted, and graded to the original profile after the measurements were taken. There was no discernible variation in behaviour before and after trenching.

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C. Strain measurement of geosynthetic materials

The distribution of strain beneath the loaded area along the wheel path appears to be very non-linear, according to the evidence. Even at low vehicle speeds, the differentiation of 'tensile strength' is visible between the 'outer' and 'inner' wheel assemblies with 2 'dual wheel'. The pattern is best evident in the thinner regions. The following is an example of a comparison. the various graphs that were interpreted after an extensive research.

TableI
Strain Measurement in Percentage

Base Course Thickness	Geo Synthetic Material	Number of Passes , N				
		12 (Strain %)	40 Strain %	80 Strain %	150 Strain %	300 Strain %
25 cm	Non woven Geo Textile	2	3	3.5	4	8
30 cm	Woven Geo Textile	3	4	4.5	6	9
35 cm	Geo Grid	1	1.5	2	2.5	6

D. Impact of Geosynthetics

When the average measured rut depth is compared to the number of passes, '25cm' thick parts are not found to be stable, and unstablility may be defined as rapidly expanding 'rut' as passes are increased. The behaviour of the unreinforced and reinforced parts differs significantly, remarkably in case of 'geo textile' . Soil with 'geo textile' reinforced take 'eight' to 'ten' era extra 'vehicle passes' as compared to unreinforced part at same rut depth, other sections that are reinforced takes 'three' to 'four' times extra passes in number than segment that is not reinforced. Contribution of the geosynthetic materials, which differs for each material, is attributed to the varied behaviour of response of '25' cm section. Even with small number of passes, the geogrid material exhibits the most improvement.

Other three geosynthetic materials follow same pattern for roughly '50' to '75' passes, and after that there is a noticeable change in performance..Figures 4.5, 4.6, and 4.7 show average depth of rut with respective number of the passes for the '35', '40', and '50' cm base course thicknesses, respectively.With increasing the number of passes, the test sections showed response defined by depth of rut which is almost same or slightly ascending. Performance of portions that are with reinforcement and without reinforcement differs significantly in '35' cm thick part, but there is not much difference in the geotextile reinforced sections and minor enhancement in ' geo grid reinforced' section with respect to 'geo textile reinforced' section.

Because this behaviour appears to be independent of stiffness, it is considered to be novel.Due to greater interlocking between 'base course layer' and 'geogrid', which impacts lateral aggregate sttlement and prevents subgrade incursion.Use of geosynthetic materials thus reduces the necessity of increased base course thickness, however an optimum result is found at increased thickness of base course.

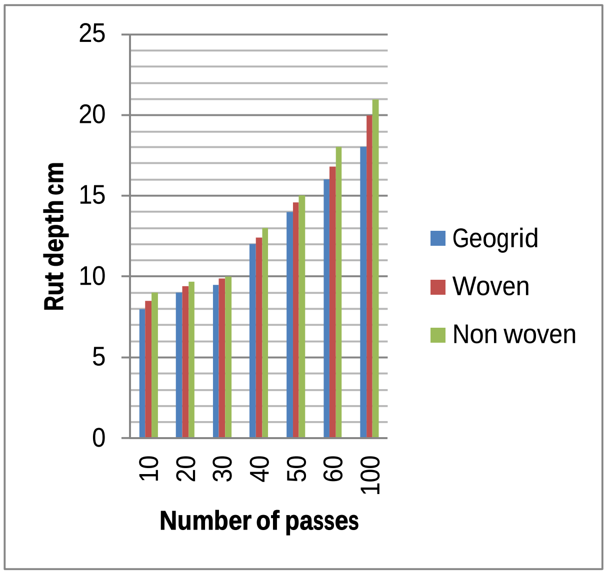

Figure 5 Rut depth vs number of 'passes' for '35' cm (base course)

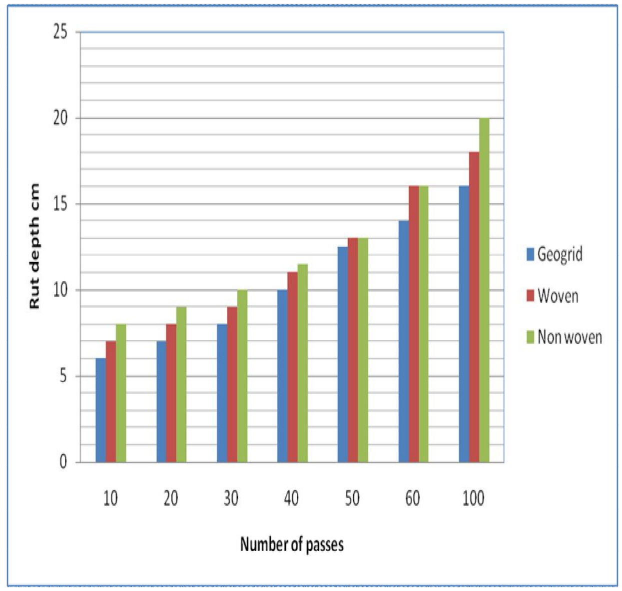

Figure 6 Rut depth vs number of passes for '50' cm (base course)

E. Performance with reinforcement

The performance of the reinforced sections is evaluated comprehensively. The parameters were based on the type of geosynthetic material used and the type and number of passes of the vehicle load used for this specific purpose.It may be noted that geo grids show promising results as compared to the geo textiles. However the ruts developed in the process were greatly influenced by the base course thickness.

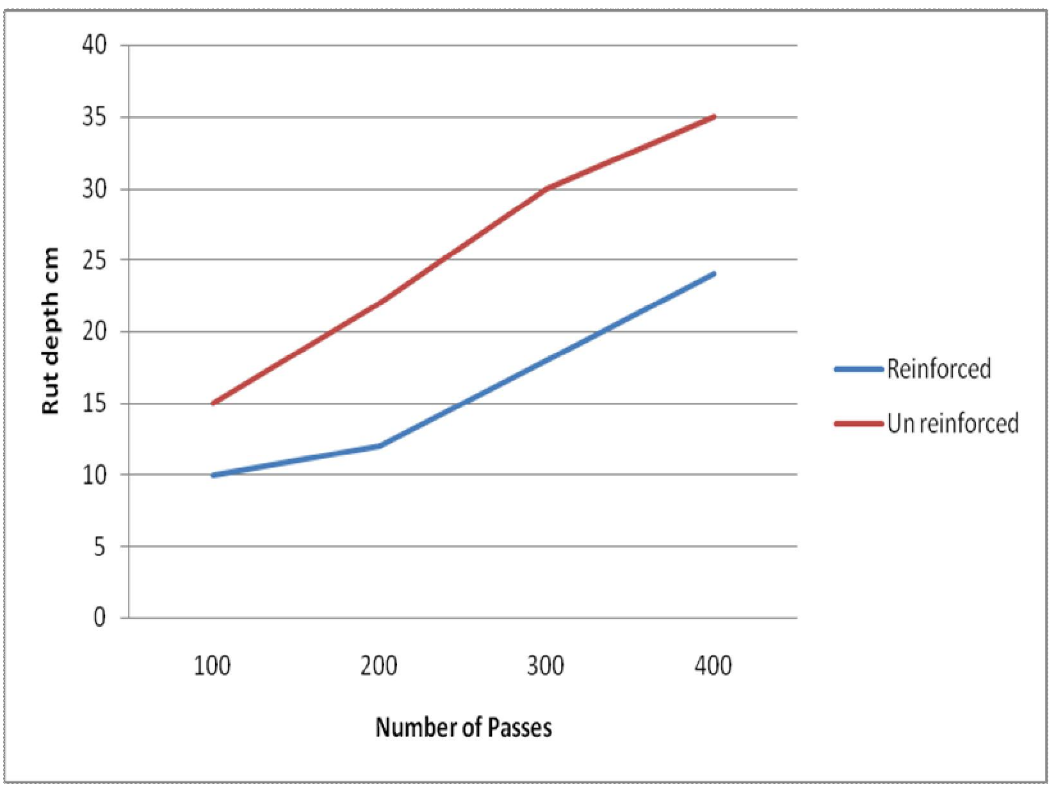

Figure 7 Performance of 'Reinforced' and 'Unreiforced' Sections with respect to number of 'Passes'

Table II

Rut depth vs number of passes for woven geo textile reinforced Section

Number Of Passes	Thickness of base course vs Rut depth			
	25 cm	30 cm	40cm	50 cm
3	5.4 ‘cm’	5.6 ‘cm’	4.7 ‘cm’	4.6 ‘cm’
6	6.2 ‘cm’	5.9 ‘cm’	5.7 ‘cm’	5.2 ‘cm’
10	8.3 ‘cm’	8.3 ‘cm’	7.6 ‘cm’	7.2 ‘cm’
15	12.5 ‘cm’	11.4cm	10cm	9 cm
30	22 cm	22.5 cm	21.3cm	17.3 cm
100	35 cm	40 cm	28.4cm	26.3cm
200	Section failed	Section failed	51 cm	48.6 cm

Table III

Rut depth vs number of passes for geo grid reinforced section

Number Of Passes	Thickness of base course vs Rut depth			
	25 cm	30 cm	40cm	50 cm
3	5.3 ‘cm’	4.6 ‘cm’	4.3 ‘cm’	4.2 ‘cm’
6	5.6 ‘cm’	5.4 ‘cm’	5.2 ‘cm’	4.8 ‘cm’
10	7.4 ‘cm’	7 ‘cm’	6.9 ‘cm’	6.3 ‘cm’
15	11.4 ‘cm’	9.5 ‘cm’	8.7 ‘cm’	8.1 ‘cm’
30	19.1 cm	18.7 cm	17.5cm	15.1 cm
100	31 cm	30 cm	28cm	24.6cm
200	34.4 cm	34.1 cm	32cm	31.6 cm

Figure 8 Formation of ruts in un reinforced section

Figure 9 Formation of ruts in reinforced section

F. Bearing capacity

Most design approaches acknowledge that when a geosynthetic is used in unpaved road building on a ground that is soft, bearing capacity failure of the subgrade is relocated from local to global shear failure, resulting in a 65 percent increase in bearing capacity. Foremost principle of research is the computation of 'bearing capacity' factor observed in the 'reinforced' and 'unreinforced' sections.Vertical stresses are estimated using Odemark (1949) method by plotting rut depths at specific intervals of vehicle passes.

Reinforced section was subjected in the same way as was the unreinforced section,. Unfortunately, for the 25 cm thick sections, variations in base course thickness are only possible up to '60' to '80' passes, as a result, vertical stresses for passes greater than that are disregarded., and the maximum possible stress value ranges inbetween 4 and 4.5..and is still less than what the theory of plasticity considers to be the stress level for the subgrade's final carrying capability. The values around '5.5', is derived from a '25' cm section and is unreliable.

Other values range between '0.8' and '3.5', showing that the subgrades maximum bearing capacity was not achieved. As a result, rather of attaining the final bearing capacity, the performance of the thinner sections may be attributable to something other than the bearing capacity factor utilised in design. Before that stress level is mobilised, the geosynthetics are ripped, leading to 'local shear failure' and less stress level than expected. Extraneous performing shear stress and total rigidity of reinforced structure are necessary in this situation.

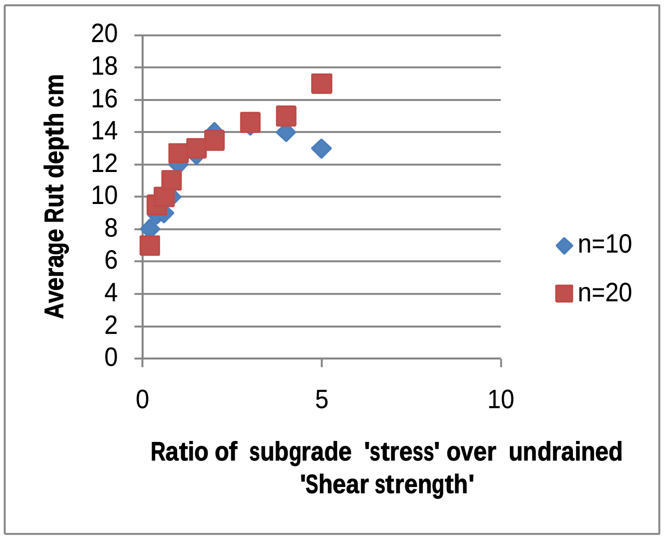

Figure 10 Bearing capacity ' factor' prediction (Unreiforced section)

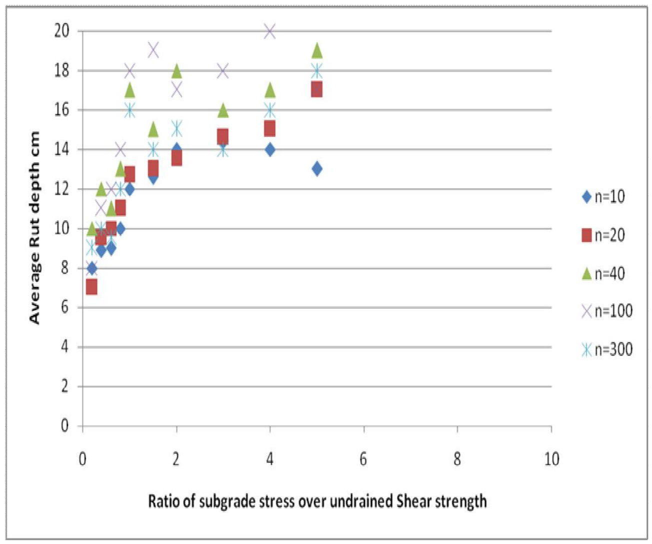

Figure 11Bearing capacity factor prediction –Reinforced section

V. CONCLUSIONS

TheReinforced test portions' field performance and testing indicate that a specific stabilisation mechanism was in operation. From the research, the following findings can be drawn.

A. The tensioned-membrane effect appears to be generated in '25' and '30' cm sections, which is especially visible in the 25 cm segment, and an evident variation in functioning presentation among 'geotextiles' which is linked with 'tensile strength' of it.

B. In the thinnest parts, separation appears to be particularly critical, and the geogrid doesn't show good performance as base course thickness increases, performance of geo grid improves dramatically, which is due to good bond with base course material..

C. When a certain number of vehicles pass by and rut depths are modest, evidence of a tensioned-membrane effect diminishes as base course thickness increases: stiffness and separation are the key factors contributing to the reinforced system's higher performance.

D. The geogrid regularly shows less rutting than the Geotextiles in 40 and 50 cm thick sections. .

E. Using geosynthetic materials in unpaved roads is well-known. However, structural parameters such as material qualities, geometry, and stress conditions influence the relative improvement of a reinforced over an unreinforced structure.

F. Few full-scale field trials comparing the relative performance of different geosynthetics under controlled vehicle loading have been conducted and reported.

G. In terms of how they interpret the reinforcement action, design methodologies differ in some ways. As a result, some of the design's essential assumptions must be proved by a controlled field trial and observing the road system's response to traffic.

H. The field trial has some limitations that must be renowned. These records are framed on power of lone subgrade.. The loaded vehicles are channalized, which is not always the case .

I. The compaction of the course layer has a significant impact on traffickability, and the compaction prior to vehicle loading in this field trial was anticipated to be less than in standard road construction practise. It's also worth note that these ground test is limited to '400' average 'axle vehicle passes', as unreinforced and reinforced portions' relative performance isn't comparable. This number of passes is used to determine the four reinforced portions.

J. over unpaved highway with depth of 'base course' among '25 cm' and '50 cm' profound over elastic soil of 'shear strength'(un drained) of concerning '40' (kPa), effect of 3 non woven geotextiles and the geogrid were evaluated.

K. The reinforced portions perform better than sections that are unreinforced inside roads that are unpaved above 'elastic sub grade', as shown by results of this site study. However, in terms of failure, each of the four geosynthetics performed similarly, with failure elaborated as undesirable depth of rut or the serviceability fatigue.

L. Base course strata was subjected to compression, that included lateral spread of gravel and associated subgrade deformations were much lower than measurement of rut at base course.

M. Because there was no substantial difference in subgrade qualities at the test site, the behaviour at low 'rut depths' was committed to firmness of bottom track in previous stage, as 'rut depth' is autonomous of base course thickness. Following that, rut formation is greatly effected by thickness of bottom course, and rut propagation is greatly effected by thickness at this stage demonstrating an upward trend as vehicle passes more and more. However, this does not happen until there is a rut of roughly 15 cm, which is unsatisfactory in many circumstances and regarded close to a serviceability failure.On the basis of these results of this study, it shows that in designing of 'unpaved road' above soft earth for little amount of passes also the slight bottom path, both the stiffness of the geosynthetic and its separation ability are critical factors to consider. It's obvious that if sufficient separation isn't supplied, stiffness becomes less useful on its own.

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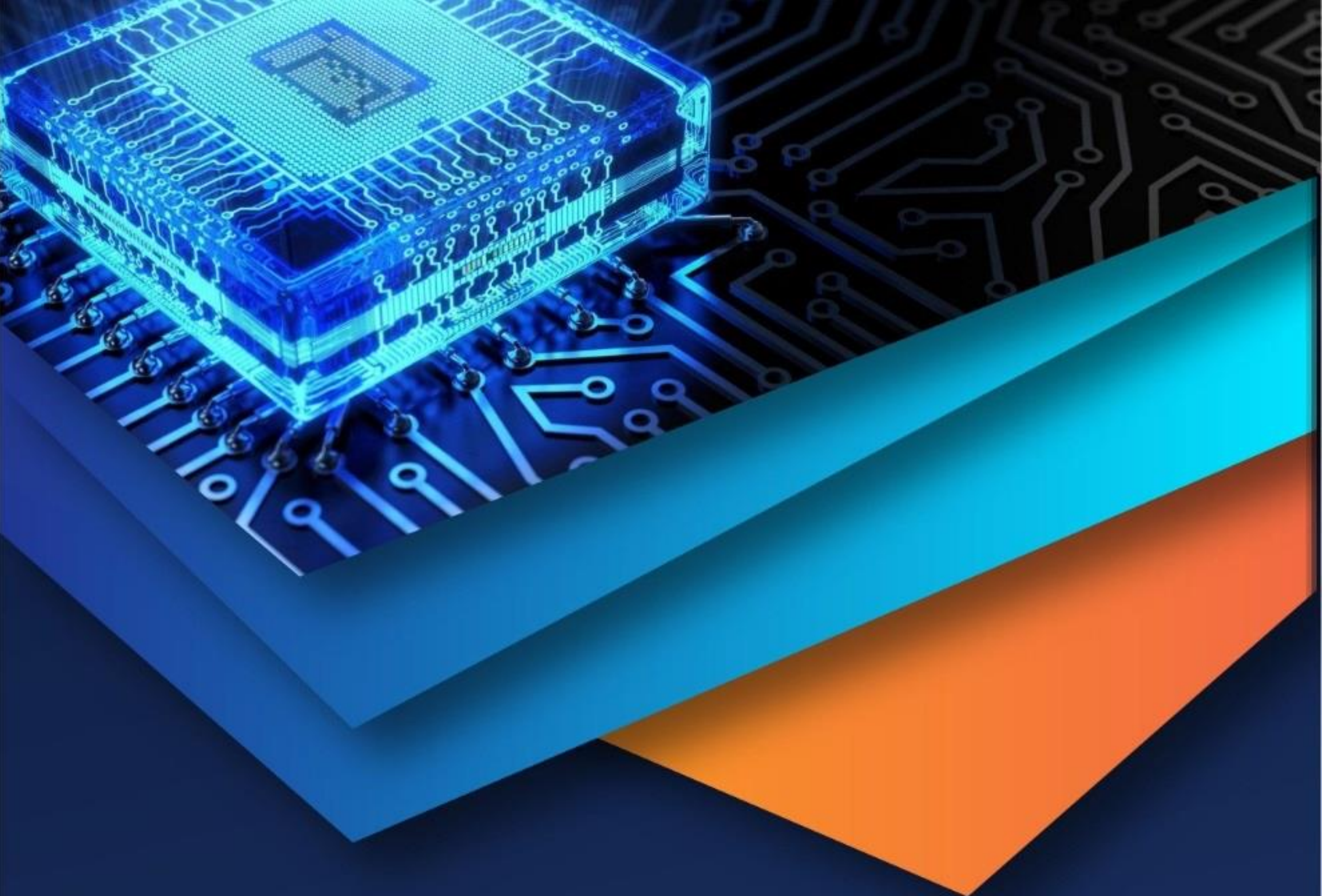

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