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A review on uses of geogrid and geotextile on road construction

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Abstract: *Transportation and geotechnical engineers find building pavement over unstable subgrade soils difficult and tough. The life of the pavement is shortened due to the deterioration of the surface, whether it is paved or not. In India, the most common issues with roads are the development of potholes, ruts, cracks, and, settlement and localized depression particularly during the rainy season. These are mostly caused by the subgrade's inadequate bearing capability when it is saturated with water. The use of soil reinforcing through a variety of techniques has expanded recently to increase the subgrade's strength and load-bearing capacity. According to field signals, Geosynthetics reinforcement will increase pavement performance. As a result, many studies have supported the usage of various geosynthetics on pavement surfaces. Geosynthetics have many uses, including containment, drainage, filtration, reinforcement, and separation.. This review mainly focuses on the application of geosynthetics for stabilising poor subgrade soil in terms of enhancing various engineering properties because improved engineering properties lead to the preservation of natural aggregate materials, a reduction in a settlement, an increase in pavement life span, and a significant decrease in maintenance costs.*

Keywords: Geosynthetic reinforcement, Geogrid, Geotextile, Soil stabilization, Road construction

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1. Introduction

The pavement construction and design aim to produce reliable pavement, by reducing the thickness of the paving layers and minimizing maintenance. The in-situ material, known as the subgrade is responsible for supporting all of the load generated by the road construction. The foundation material for pavement performance is the lower layer of pavement. The subgrade's properties for instance its stiffness and load-bearing capability, affect the effectiveness of the pavement. To reduce the pavement, weak subgrade soil might be substituted with a stronger one or stabilized with cement, lime, or fly ash [1]. The engineer's biggest challenge when building highways in India's plains and coastal regions is the existence of soft soil at ground level. Construction of roads over loose soil is expensive since it requires granular materials to be thicker. Some Indian states located in high-rainfall areas experience poor drainage and weakness. This is one of the main reasons for the poor status of the roads in those states. By utilizing geosynthetics, poor soil can be strengthened and pavement can be built affordably, with high quality, and with less frequent maintenance. There are various applications of Geosynthetics such as separation, reinforcement, filtration, drainage, containment, etc. Two of the key geosynthetics functions, separation and reinforcements are carried out by geogrids and geotextile when they are used in a pavement system. Its uses in geotechnical engineering projects like roads, railroads, and airports, geosynthetics are discovered to be a valuable operational replacement to repair weak sub-soils in such a region where the soil quality could be poor and there could not be any suitable soils available. Numerous products in the geosynthetics category that serve as reinforcements are used to solve a wide range of geotechnical and transportation issues. Major reinforcing applications for strengthening weak soil subgrades [2]. A geosynthetic reinforced subbase is typically constructed over relatively soft subgrades and can support a thinner base layer and surface course above. To provide the necessary support for the pavement surface, thick granular and base course layers are frequently substituted for soft subgrades in the conventional and generally higher-cost alternate approach for highway construction. As a result, geosynthetic products are used more commonly in road networks than in other kinds of civil engineering structures, especially in rural areas where it is important to support and reinforce the weak soil layers for temporary or long-term highways.

2. Geosynthetic

According to the American Society for Testing and Materials (ATSM) Committee on

Geosynthetics, planer products made of polymeric materials that are used with dirt, rock, earth, or other components related to geotechnical engineering as a crucial component of a man-made project, structure or system are known as geosynthetics. The term Geosynthetics refers to a variety of polymeric compounds used in civil engineering construction projects [2]. Geosynthetics products are successfully used in pavement design, separation, and filtration reinforcement. Geosynthetics also served as filters by regulating how soil particles are transported from the subgrade to the base material. There are several different kinds of geosynthetics including geotextiles, geogrids, and geomembrane [3]. They are polymeric goods that are utilized to address engineering challenges. This consists of the following eight major product categories, clay liners, geotextiles, geogrids, geonets, geomembranes, geofoam, geocell, and geocomposites. When a high level of durability is needed in the ground, the product's polymeric composition makes them ideal for usage. Furthermore, they may be used in open applications numerous [4] shapes and materials are available for geosynthetics. These materials have a wide range of applications and are currently used in a number of civil, geotechnical, transportation, geo-environmental, hydraulic, and private development applications, including those for roads, airfields, railroads, embankments, retaining walls, and sediment management., landfill liners and landfill covers, as well as in mining aquaculture and agriculture [5]. Stabilization is employed in many engineering projects, with highways and airport runway pavements seeing the most frequent use of geosynthetics [6]. These projects' main goals are to increase soil stability or strength and lower construction costs. The three most common uses of soil reinforcement with geosynthetics are to: 1) strengthen the base of embankments constructed on incredibly weak foundations; 2) stabilize and steepen slopes; and 3) reduce the soil pressure behind retaining walls and abutments. Geosynthetics enable the first two uses of buildings that would not be economically or technically possible without them. Retaining walls can be built more affordably than they would otherwise be by using unconventional methods. Additional reinforcement and stabilization uses for geosynthetics include highways and railroads, large-area stabilization, and natural slope reinforcement [7, 8].

2.1 Geogrids

Among their types, the use of geogrid in enhancing road paving is growing in popularity. Polymer materials like polypropylene, polyethylene, or polyester are frequently used to create geogrid. "They can be made by weaving or knitting yarns, heat-welding strips of material, or punching holes in sheets of material that are subsequently stretched into a grid. The primary function of geogrid is reinforcement.

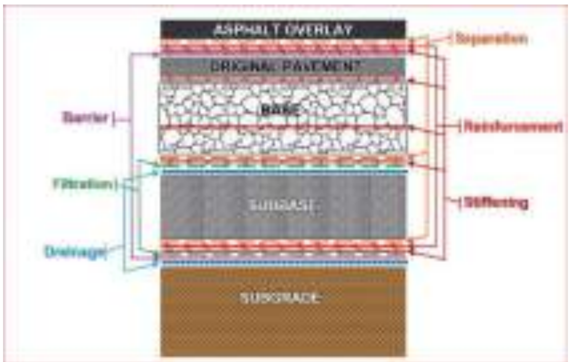
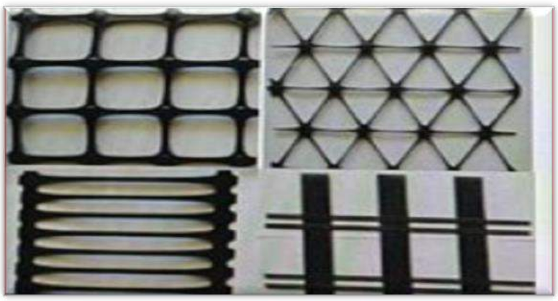


Figure 1: Functions of geosynthetic in roadway applications [9].

The discovery of techniques for moderately rigid polymeric material preparation through tensile drawing opened the door to the possible use of utilizing such elements to strengthen wall-building soils, steep slopes, road bases, and foundation soils [10]. By lateral constraints of the base and subgrade or



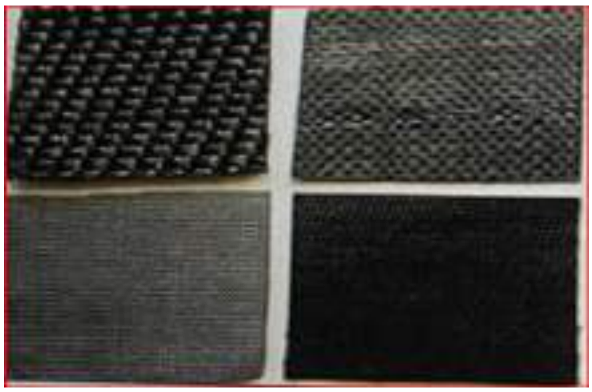
by increasing the system bearing capacity, geogrids enhance the performance of the pavement system.

Figure 2: Geogrids [11].

Polymeric Geogrids are also used in situations where a higher reinforcing strength is required. Due to their tensile strength and ability to interlock fine soil with coarse soil, geogrid open aperture between ribs also serve to provide a bond for the covering material.

2.2 Geotextile

A subcategory of geosynthetic known as geotextile is composed of materials made of polymers like polyester or polypropylene. When used in association with soil, geotextile is a permeable material that can separate, filter, be reinforced, protect, or provide drainage. Geotextile materials have a wide range of applications. The main purpose of geotextile materials is to reduce stresses and deformations while also increasing the bearing capacity and longevity of the ad hoc layers. Applications of geogrid and geotextile in road construction.



2.3 Geogrid

The quality and durability of the pavement were significantly influenced by the materials used for the subgrade, subbase, and base course. The most important of them is the type and quality of the subgrade soil. However, most flexible pavements in India are constructed over a subgrade that is inadequate and dangerous. These subgrade's CBR is so low that additional thickness is required. A search for an affordable method of transforming locally accessible problematic soil into usable building materials for constructing pavement. As a practical way to improve the properties of naturally occurring soils, geogrid reinforcement is gaining more and more acceptance [12]. Geogrids increased the system's bearing capacity, literate restrained the base and subgrade, and mechanically improved the engineering properties of the pavement system to improve the performance of the pavement. The best placement for geogrid is on the subgrade surface and beneath the subbase material. He claims that polymers like polyethylene, polyvinyl alcohol, and polypro the geogrid act as reinforcement in this area through lateral restraint of the subbase, enhancing the pavement system's load-bearing capacity and lowering shear stresses on the subgrade. These are mostly a few of the many polymers that make up geogrid, a geosynthetic material [13].

Due to their rigidity and tensile strength, the open geogrid apertures between ribs enable the interlocking of fine and coarse soils, as well as the bonding of the materials they are overlaid with. The interaction caused by the geogrid's interlocking with the aggregate reduces vertical subgrade deformation and minimizes lateral movement of the aggregate particles. These polymer-based materials' ability to be made by using them in line with their specifications, their lightweight designs that make them easy to transport, and their utility as simple-to-use building materials as opposed to conventional building materials. Carrying the shear strains caused by traffic loads at the interface is one benefit of geosynthetic reinforcement at the base course and subgrade soil interface. Higher tensile strength geogrid performed better than lower tensile strength geogrid two types of failure can occur when a subgrade soil is loaded beneath a surface, whether paved or not: localized shear failure and bearing capacity failure. When loads exceed the subgrade strength, localized shear failure tends to show itself in soft subgrades as significant deformation or rutting. Soft soil subgrades with a geogrid reinforced with granular fill may significantly increase the subgrade's effective bearing capacity by preventing localized shear failure [14].

The CBR test, which specifically analyses the ratio of the test load to the standard load by a standard plunger, is used to assess the subgrade's strength. The mechanical strength of the materials used to build roads is frequently assessed using this test. It was found that for both laboratory and field studies, the CBR value increases in the reinforced case compared to the unreinforced condition. This was accomplished by using Geogrid as reinforcement. Using geogrid as the sole layer of reinforcement has reportedly lowered the potential for expansive clays to expand, according to certain studies [15].

2.4 Physical and geometric characteristics of Geogrid

The geometric layout and material characteristics of a geogrid define its characteristics. The thickness, aperture size, and per cent open area of the grid, which make up its geometry, significantly affect the mechanical qualities. The aperture size must be adequate to allow the soil and aggregate to pass through and bond to the geogrid. The composite behavior required for soil stabilization is produced by the interaction between the geogrid and the surrounding soil. A geogrid's open area normally ranges from 50% to 60%. The thickness of the grid includes the rib and junction thicknesses, which must be substantial and rigid enough to allow the striking through of surrounding soil, stone, or other geotechnical material [16]. Typically, the ribs are thinner than the geogrid connectors. The geogrid's physical characteristics, including creep, tensile modulus, junction strength, and flexural rigidity (ASTM D7748), are crucial for meeting the design and serviceability standards [17, 18]. When stress circumstances are more immediate, a higher geogrid tensile modulus becomes crucial [19]. In addition to rib strength, junction strength is a feature that is often used as a gauge of manufacturing standards and can provide information about the stability of the grid and the possibility of tension reinforcement [15]. Flexural stiffness, which refers to a geogrid's resistance to bending, is an excellent indicator of the material's inclination to fold or wrinkle. Geogrids' mechanical features and behaviour are significantly influenced by the form of their aperture. Samples of high-strength polyester yarn coated with polyvinyl chloride (PVC) and cured at 180 C were studied to determine the effect of the size of the aperture and soil on the pull-out strength of the geogrid material [20]. The reduced hole size led to incorrect soil and geogrid interlocking, which produced extremely disperse results. As the aperture size grows, the frictional force between the soil and the geogrid decreases. In both extreme cases, there was less pull-out resistance. The soil with the largest particle size, however, had the maximum pull-out resistance due to its enhanced interlock. Additionally, the density of the ribs in the transverse direction had a greater impact on the pull-out resistance [21]. Results demonstrate a direct connection. Aperture size and pull-out test outcomes are directly correlated, according to the results [22]. When the aperture size is comparable to the size of the soil grain, the geogrid and soil interact as much as possible [23]. The characteristics of four different biaxial geogrid materials used to stabilize the pavement subgrade were examined using accelerated pavement testing (APT) for pull-out and shear. APT makes it possible to quickly complete testing while controlling the loads and environmental factors. The study suggests that while selecting a geogrid, the aperture's dimensions, the geogrid's strength, the node strength, and the resistance to bends should all be taken into account [24]. It was discovered that the tensile strength and stiffness of rectangular aperture geogrids are direction-dependent. In relation to the orientation of the ribs, the uniaxial loading determined the strength. Higher tensile properties could be achieved by loading the geogrid either in the machine or cross-machine directions [25]. The tensile strength decreases as the load is orientated away from those directions. Contrarily, the geogrids with triangular apertures evenly distributed the load in all directions of loading. In addition, compared to rectangular geogrids, those triangular aperture geogrids showed improved stress distribution. Therefore, it appears that the triangular aperture geogrid is more efficient in carrying off-axis stresses that are not parallel to the main directions.. The body appears stiffer because of the presence of ribs [26].

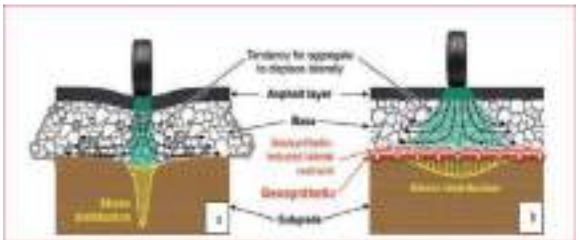


Fig. 4: Use of geosynthetic in road base stabilization: (a) roadway design without geostnthetics, (b) roadway design with geosynthetics [9].

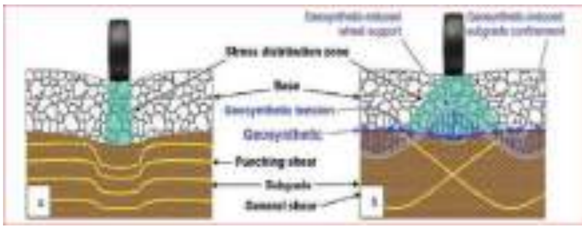


Fig. 5: Use of geosynthetic in road subgrade stabilization: (a) roadway design without geostnthetics, (b) roadway design with geosynthetics [9].

Numerous studies have been done to determine how effective it is to use geogrid reinforcements for subgrade stabilization.

On geogrid-reinforced unbound aggregates, Byun and Tutumluer (2019) performed triaxial testing. In the triaxial test sample, two bender elements were inserted, one was near and another one that far from the geogrid. The outcomes demonstrated that the geogrid's proximity to the aggregate layer improved its shear modulus. Because the geogrid layer had little impact near the ends of the sample, the shear modulus was comparable to that of the unreinforced model. Also discovered to be lower than the unreinforced model was the geogrid-reinforced model's permanent strain [27] the strength of subgrade soil in unpaved roads was tested using CBR on geogrid-reinforced soil by Singh et al. (2019). Different types of single-layer and double-layer geogrids were inserted and tested at various depths in the CBR sample. The base course layer's thickness is reduced by reinforcement since it raises the subgrade's

CBR value. One layer of reinforcement added to the subgrade enhances the soil's CBR value by 5 to 60%, while a 39-double layer of reinforcement boosts strength by 112 to 325 percent. Additionally, the analysis provided the ideal depths at which different geogrids should be positioned [22].

Carroll et al. [16] studied the geogrids utilized in paved roads' reinforcing methods. They stated that, based on equal load deformation performance, geogrid reinforcement allows for a reduction of 50% in the granular base's thickness while still reducing permanent deformations in flexible pavement systems. Geogrid-reinforced lightweight aggregate beds were the subject of an experimental examination by Schriver et al. [28] to determine their subgrade modulus and raise the bearing capacity ratio. The experiment revealed that paving road lifespan is greatly increased by adding reinforced geogrid at the sub-base/aggregate interface. A more equal load distribution and a decrease in the maximum settlement are provided by geogrid reinforcement at the interfaces between aggregate and subgrade and asphalt.

On the geogrid reinforced pavement model over a weak subgrade, Milligan et al. [29] performed full-scale monotonic plate load testing. According to the study, adding geogrid reinforcement resulted in a 2-inch increase in pavement thickness at a 1.5-inch settlement. According to the study, geogrid reinforcement is also more successful in base course materials with lower levels of stiffness, and its effects are noticeable at high deformations. Further improvement is made possible by the geogrid's interaction with the aggregate.

To investigate the performance enhancement of geogrid and geotextile reinforced pavements, Chan et al. [30] carried out comprehensive field testing. The study used a subgrade with a CBR of 2.6% covered with a granular layer that was crushed at the proper moisture level. The geosynthetic initially received a granular column application for an hour, followed by a moving wheel load with each wheel weighing 6.6 KN and exerting a pressure of 550 kPa. The wheel's speed ranged from 3.8 to 4.8 kmph. Prestressing was found to have a considerable impact on performance. However, due to stress reduction over time at the place, it is debatable.

Giroud and Han [31] examined the effects of the geosynthetic fabric's tensile strength at 5% strain using the field research done by Watts et al. (2004).. The design mechanisms for geosynthetic reinforced pavements used this criterion. The traffic was launched with single- or double-wheel loads of axle weights of 40 KN, and it was subjected to traffic at a speed of 15 km/h. The CBR of the subgrade was 2%. Each geosynthetic employed had its traffic benefit ratio determined, and the graph demonstrates that there is no connection between the two parameters' tensile strengths at 5% strain. Tensile strain at 5% strain, according to Giroud and Han, cannot be used as a design factor for pavement. Geotextiles with a high modulus would function better than geogrids since the tension membrane mechanism only works when the rut depth is greater than 75 mm. As a result, a new parameter for the design of reinforced pavements must be taken into account.

Moayedi et al. [32] researched the effectiveness of geogrid reinforcement set up in three different places. (i.e., 50, 25, and 5 cm from the model's base). They discovered that the geogrid's effectiveness is greater when it is positioned at the base of the surface layer after discovering that both shear stress and normal stress enhanced when the geogrid was positioned beneath the centre of the load at a distance that caused vertical deflection. This was done just beneath the asphalt layer.

The deformation of weak subgrades under loading was investigated by Barksdale et al. [33]. When a geogrid was placed on the subbase course's bottom, they observed a 52% decrease in permanent subgrade deformations.. Additionally, the use of geogrid reinforcement decreased overall rutting in subbase material and subgrade soil by 20 to 40%. Al-Qadi et al. investigated at how using geogrid reinforcement affected the extent to which the pavement worked. In order to record displacements, the pavement surface was loaded to 550 kPa. The findings showed that for 25 mm of permanent deformation, the pavement portions stabilized with geogrid exhibited 1.7–3 times greater resistance than those produced without geogrid [34].

Flexible pavements for light aircraft were examined by Webster et al. for geogrid reinforcement. They discovered that adding geogrid reinforcement between the layers of aggregate and subgrade enhances the performance of the pavement. Their results showed that in the presence of a weak subgrade, geogrid stabilized pavements can sustain about 3.5 times more traffic load repetitions [35]. Perkins et al. found that adding geogrid reinforcement increases the vertical stress distribution over the subgrade and the modulus of the base layer. Geogrid-reinforced unpaved roads on soft subgrades were subjected to comprehensive field experiments by Hufenus et al. [36]. They discovered that geogrid reinforcement improves the pavement's carrying capacity and lessens the development of ruts.

Large-scale direct shear tests were used by Tang et al. [37] to investigate the effects of geogrid characteristics on subgrade stabilization. They demonstrated that the mechanical and physical characteristics of the geogrids as well as the characteristics of the interface efficiency of geogrid reinforcement is significantly impacted by the interface between the geogrid and other materials. By carrying out direct shear testing, they assessed the geogrid reinforcement's interface effectiveness. They discovered that other metrics acquired from the extensive direct shear testing, such as the junction strength and tensile strength at 2% strain, showed a high connection.

Ling and Liu [38] tested model sections both statically and dynamically to determine the contribution of geosynthetic reinforcement to the strength as well as stiffness of asphalt pavements. Above the subgrade, the reinforcing layer (geo-grid) was installed, and then the final asphalt concrete layer was added. According to the research, reinforced pavement settled less than unreinforced pavement across the loading area.

Srinivas Rao, B., and Jagloxshmi S. [39] investigated the impact of fibre reinforcement on the soil subgrade under flexible pavements. In this work, a study was done on the use of polymer reinforcement to strengthen the soil subgrade. For the CBR test, it was decided against using fibre reinforcement. The CBR value of fibreless soil is 3.3%.

In 2010, Professor Staling, V.K., Professor Ravi, E., and Arun Murugan, R.B. conducted an experiment employing geosynthetics to investigate expensive clay's shrinkage behavior. In this work, made an effort to use geosynthetics to regulate the expansion of swelling clays. Swelling tests on expensive clay with various orientations and including layers of geo-grid, geo-membrane, and geo-textile revealed that the clay with geo-grid has a strong load-carrying ability [40, 41].

According to Raju, N. Ramakrishna [42], geosynthetic materials are used in earth dams and embankments to increase stability. Building time, site acquisition, and building material amounts are all reduced when an embankment or infill is reinforced on soft soil.

Moustafa Ahmed Kamel, Satish Candra & Praveen Kumar [43], during the research, two crucial characteristics were looked at. The first thing that was covered in the learning process was the ideal placement of just one geogrid layer and the subgrade's strength properties. The second was a demonstration of stabilized subgrade soil under cyclic loading conditions. After taking into account the risk of failure deviator stress, elastic modulus, and strength rate, the region with the highest strength was selected. When the geo-grid is positioned between 72% and 76% from the uppermost layer of the subgrade, according to CBR and Values, which increase with reinforcement, the geo-grid produces the highest values. The findings of the cyclic triaxial tests indicate that the resilient strain is 35% lower in unreinforced soil than in reinforced soil. Furthermore, the permanent strain in reinforced samples is 44% lower than in unreinforced samples, making geogrids essential for managing rut development in pavement design.

Meenakshi Singh [22], the CBR value of unpaved roads has been assessed in this study. Geosynthetic reinforcement placed in subgrade soil at various depths is being investigated by subgrade soil performance. In order to determine the ideal depth of reinforcing layers, laboratory CBR tests were carried out. In the CBR mold, one layer of geosynthetics is placed every third, fourth, and middle distance from the soil's surface. The results show a decrease in the pavement's thickness and an increase in the CBR value of the subgrade soil. Reinforced soil performs better than unreinforced soil, according to this study. The layer was put between 0.41H and 0.62H, which was determined to be the best place for reinforcement.

Gosavi et al. [44] also investigated the strength behavior of soils reinforced with mixed geogrid woven fabric, and they discovered that the soaked CBR value was approximately 4.9% before the application of the geogrid, and test results following the uses of the geogrid demonstrated an increase in the CBR value. According to Naeini and Moayed, in a soil sample with a different plasticity index, using a geogrid at the top of layer 3 produces a considerably greater CBR value than unreinforced soil for both soaked and unsoaked conditions. The reinforcing ratio is taken into account to determine how much the penetration resistance has increased.

Pradeep Singh, K.S Gill, [45] aim of this research is to ascertain the impact of geogrid reinforcement on Maximum Dry Density (MDD), California Bearing Ratio, and subgrade soil value. For this investigation, a geogrid of a certain type and a soil type that is clayey soil was chosen. The analysis demonstrates that the California Bearing Ratio of the subgrade has dramatically increased due to the reinforcement of the geogrid. Without reinforcement, the soaking CBR value was 2.9%, and when the geogrid was placed at 0.2H from the top of the specimen, it increased to 9.4%.

Ayush Mittal and Shalinee Shukla (2019)- Analyse the findings of a lab experiment to see how polyester biaxial geo-grid affects the strength and performance of weak subgrade soil. In this study, clay was utilised as the soil type. According to IS 1498 (1970), clay has an intermediate compressibility rating, contains a sizable proportion of fine soil, and weakens when moisture content changes. At various locations in the soil subgrade, geo-grid sheets are employed as both single and multiple layers. The CBR ratio and the unconfined strength test are conducted. The study specifies improvements in strength value in the form of CBR, UCS, and axial strain at failure. The subsoil subgrade from the top of the surface reinforced with geogrid with one and more layers results in maximum increases of 40% in Strength value and 70% in UCS values, respectively. To examine the micromechanical interaction between the geogrid's surface and the soil, scanning electron microscopy (SEM) is used. Surface friction and the interaction of soil particles with geogrid fibres have been identified to be the primary factors in the strengthening of weak subgrade soil [46].

Nair et al., 2009-They investigated the effects of utilizing biaxial geogrid and polypropylene woven geotextile to reinforce substandard soil. At varying water contents of 13%, 14.5%, 16%, and 17.5%, the laboratory California Bearing Ratio test was performed on soil alone, soil with aggregate, soil with aggregate and geogrid and textile. For all water contents, the soil-aggregate-geogrid-geotextile system showed the greatest improvement in CBR value [47].

Zornberg et al., 2009- They investigated about how geogrid reinforcement reduced longitudinal cracks brought on by pavements built on clayey soil subgrades. Three field survey of pavements built in the Fort Worth-Dallas region of Texas were conducted. The use of geogrid reinforcement has been found to efficiently relocate potential longitudinal cracks outside of the reinforced zone, minimizing the formation of longitudinal cracks. Additionally, it has been discovered that the geosynthetic reinforced area exhibits cracks as a result of the geogrid connection falling from a lower junction efficiency [48].

Oğuzhan Bayraktar (2020)-investigated the impact of soft clay reinforcement and the plasticity index on CBR values. By adding bentonite, three separate soil samples of varying plasticity index (PI) were produced. It was found that the strength of the unreinforced soil decreases as the PI value increases while the California bearing ratio increases. Geogrid GS50, which has a weight of 300GSM and is constructed of low-density polyethylene fibers, was employed as reinforcement. Adding a single layer of geogrid (at the top of layer 3) increases CBR by 40% in all soil samples with different PI values when the soil isn't saturated. However, compared to an unreinforced one, the CBR values for two-layer geogrid addition (at the top of layers 2 and 4) increased by around 35% under wet conditions [49].

Samuel Kwofie et al - When unbound soils are reinforced using geogrid, the mechanism by which strength develops is not well understood. With a minimal focus on the influence of soil qualities on geogrid performance, the majority of geogrid reinforcement research has tended to concentrate on "humanizing" the geogrid's characteristics. This lesson looked at how lateritic soils' flexibility index and gradation qualities affected the strength of a compound made of soil and geogrids for pavement.

Three soil samples were compacted and reinforced both with and without the use of geogrid reinforcement, each with varying degrees of flexibility and gradation. Within the compacted sample height, one and two layers of geogrid were employed as reinforcement at varying depths. The findings showed that when soil flexibility increased, the CBR decreased [50].

Evangelin Ramani Sujatha et.al [51] to strengthen unstable soil provides geo-grid reinforcement. California Bearing Ratio experiments were carried out in single, double, and triple layers of soil with geogrid inserted at various depths within the sample and discovered that placement of the geogrid at a distance of 2/3 from the base results in the best performance in the single-layered came to the conclusion that Geo-grid increases the strength of the sub-grade soil in both soaked and unsoaked conditions by finding that the California Bearing Ratio value of 3 layers of Geo-grid is lower than 2 layers but higher than 1 layer, demonstrating that adding Geo-grid reinforcement to the sub-grade in a single or multilayer reduces the thickness of the pavement by increasing the soil's strength.

Naeini et al.-2009 investigated the impact of soft clay reinforcement and the plasticity index on CBR values. By adding bentonite, three separate soil samples of varying plasticity index (PI) were produced. It was found that the California bearing ratio and, consequently, the strength of the unreinforced soil decrease when the PI value increases. The reinforcement used was Geogrid GS50, which is made of low-density polyethylene fibres and weighs 300GSM. Under unsoaked conditions, adding a single layer of geogrid (at the top of layer 3) results in a 40% increase in CBR for all soil samples with different PI values. But in wet conditions, the CBR values for two-layer geogrid addition (at the top of layers 2 and 4) increased by about 35% in comparison to an unreinforced one [52].

Yash P Badwey et al. Their study looked into the use of geo-grids as a kind of road construction reinforcement when applied to sub-grade material. Poor soils become significantly stronger when the geo-grid is added, as evidenced by the increased CBR values. The highest sub-grade strength has been noted to be attained when it is placed at 3H/4 for a single layer, although having good results at H/2 and H/4, respectively. The performance of the subgrade in the unsoaked state significantly improves after soil reinforcement. Its strength is increased when weak soils are reinforced with geo-grids. It extends the pavement's final useful life and is durable since it cannot biodegrade. As an effective and cutting-edge method of enhancing road construction on subpar subgrade materials, the use of Geo-grids ought to be encouraged [44].

Table 1: CBR Value Variation with Geo-grid Application in Soil Sample [53].

Descriptions	CBR Value
Without geogrid	1.67
With geogrid @ H/4 from the bottom	1.80
With geogrid @ H/2 from the bottom	2.50
With geogrid @ 3H/4 from the bottom	3.91

Charles A. Adams et al. In this investigation, a lateritic gravel sample was interfaced at layer 3 using two different types of triaxial geogrids, Tx170 and Tx160. Without a geogrid, the sample was examined in both moist and dry conditions. The soil sample was then subjected to CBR tests by adding the geogrid to the third layer. The research's test results demonstrated that adding one layer of any geogrid to the top of layer 3 in the soil samples significantly increased the penetration resistance, which improved the CBR value. The investigation also revealed that the Tx170 geogrid supplied more resistance than the Tx160 geogrid. The use of geogrids in road building is advantageous economically since it eliminates the need to fill borrow pits with materials in order to strengthen poor soils, according to the research above [54].

Table 2. CBR Tests Results (Soaked and Unsoaked) [55].

Sample	Soaked			Unsoaked		
	Dry density (kg/m^3)	CBR Value	% increase in CBR	Dry density (kg/m^3)	CBR value	% increase in CBR
Without Geogrid	2406	50.31%	-	2101	71.7%	-
With Tx160	2239	56.1%	12%	2202	90.5%	26%
With Tx170	2266	65.71%	31%	2295	101.3%	41%

Singh and Gill conducted experimental work to establish the best location to provide geogrid reinforcement in subgrade soil by carrying out CBR and unconfined compressive tests. Geogrid reinforcement at 0.2H from the top greatly improves the subgrade soil's CBR value and stress-strain behaviour [56].

Hossein Moayedi et. al-provides geo-grid reinforcement into paved roads to enhance traffic efficiency. In his experimental study, he places geo-grid reinforcement at three distinct locations, namely 0.5 metres, 0.25 metres, and 0.05 metres from the model's base. He found that the maximum shear stress and normal stress increase when the geo-grid is placed 0.5 metres from the bottom.He also noted that the usage of geogrid immediately beneath the asphalt layer minimizes the vertical deflection beneath the load's centre, and He got to the conclusion that the geogrid's effectiveness is increased if an effective bend is maintained among the asphalt concrete and geogrid. For AC, the author has employed a FEM model. The author used a FEM model for AC pavement, but there was no logical relationship between the data that were obtained. The results have not been empirically tested by the author using tests like the California Bearing Ratio or by testing them on sub-grade soil [32].

Aga, S.Y. -This research demonstrates the use of a geogrid material made in-country for strengthening expansive subgrade soil. In the southern section of Modjo town, in the rift valley region of central Ethiopia, samples of the dark, soft soil that dominates the research area were taken. The expansive of the extremely plastic-soft soil was identified and categorized using X-ray diffraction and index property testing. Investigated are the impacts of two locally produced geogrid reinforcing materials, high-density polyethylene (HDPE) and polypropylene (PP), on the California bearing ratio (CBR) values of the expanding soil. According to the results of the test, adding geogrid reinforcement can greatly increase a subgrade soil's ability to support the weight. The use of PP and HDPE type geogrid, positioned at 0.35H from the top of the sample, was able to increase the soaked CBR of the untreated soil specimen, which was around 2.98%, to 10.16% and 7.48%, respectively. The study showed the possibilities of using geogrid material made in-country for strengthening subgrade soil [53].

Sarika Dhule et. al-In her experimentation, she makes independent attempts to modify the properties of soft murram and poor sub-grade soil by adding geo-grid at various percentages, including 1%, 2%, 2.5%, and 3%. She discovered that the California Bearing Ratio value increases with the addition of geogrid. She also discovered the impact of 2% cement and various geo-grid percentages on the California Bearing Ratio value of murrum in her experiment. More geo-grid at a 2.5% increment increases the California Bearing Ratio rating. For additional tests of the California Bearing Ratio, the author employed compacted soil. The shear strength and low permeability are the attributes that have an impact on the compaction characteristics, the author further noted. The compaction of the soil in question is therefore a factor in the outcomes [55].

Dr. D.S.V. Prasad et. al- A flexible pavement model was made, with a 0.5 m expansive soil sub-grade at the bottom that was compacted in 10 levels, and Several reinforcing materials, such as Geo-grid, bitumen-coated chicken mesh, bitumen-coated bamboo mesh for reinforcement with waste plastic, and waste tyre rubber, were dispersed evenly throughout two layers of gravel sub-base that were each 0.07 m thick when compressed. The sub-base material that two layers of WBM-II, each 0.075m thick when compacted, were deposited on. The cyclic plate load test was used to determine the best alternative reinforcement for rigid pavement. It was discovered that adding alternative reinforcing material lowers the flexible pavement system's total and elastic deformation values. The highest load-bearing ability, then the lowest value the geo-grid reinforcement has a higher maximum load-carrying capacity and a lower rebound deflection value than any other reinforcement offered. The author's work primarily focuses on the use of waste plastic, chicken mesh, bamboo mesh, and geo-grid as reinforcing materials. The results thus far collected do not clearly show which reinforcing components contributed to the increase in sub-base strength [57].

According to a study by V. Gayathri Devi on the experimental evaluation of a geogrid-reinforced subbase over soft soil, the penetration resistance and CBR strength of the soil increase when it is interfaced with a geogrid material in both moist and dry situations. As a result, the use of a geogrid enhances the functionality of a subgrade material in a pavement system. Soil's CBR value increased by 50% to 100%. When a single layer of geogrid is placed on top of the soil sample, the performance of resisting penetration is effective for dry soil samples compared to wet soil samples. Geogrids in the soil allow us to lower the base course thickness [58].

2.5 Geotextile

A geotextile is a permeable textile fabric that is utilized in combination with soil, rock, debris, or another geotechnical engineering material as a component of a building project structure or system, according to ASTM. Polyester, polypropylene, and polyethylene are the three main components used to create geotextile. Geotextiles are primarily divided into three types of fabrics: woven, nonwoven, and knitted. They are working by the project demands. The interaction of the soil and geotextile component of the composite can increase the soil's stiffness and load-carrying capability. In modern engineering practice, geotextile, a reinforcing material formed of thin, permeable sheets of synthetic fibers, is often utilized to support foundations, slopes, crushed stone columns, road pavements, etc. Numerous investigations carried out by different experts in recent years indicate that the geotextile utilized in every research project has a substantial impact on the soil's characteristics [59]Geosynthetics (geotextile) is one of the materials used in geotechnical engineering to enhance the soil's quality[33]The tensile resistance capacity of soils has increased as a result of the use of geotextiles. As a result, the soil's ability to support loads and stability both improved. By using geotextiles to improve soil, it is possible to increase the soil's rigidity and load-carrying capacity. This is made possible by a slight connection between the soil and the geotextile. Thus, if the soil supporting the road crust is weaker, the road's crust will be thicker, increasing construction costs and making it more likely that the road pavement will fail soon. However, by using geotextile, this cost can be reduced because the road pavement will be made using the original soil resources discovered on the construction site. Rather than having to be brought in from a borrow pit. In almost all areas of geotechnical engineering, geotextiles are used, and there are practically endless possibilities for their use [33]. One of the regular applications of geotextiles in the construction of roads and soil stabilisation occurs when low-strength and delicate soil conditions are present. In this application, a structural supporting layer is typically created by combining the geotextile with locally accessible material, such as crushed stone, gravel, or seashells. The two main aspects that affect how well soil performs are the geotextile's tensile strength and the interaction between the soil and the geotextile. The behavior of the soil-geotextile interface may change depending on the number of particles in the sand [60]. Unpaved roads can be built in poor subgrades at a reasonable cost by reinforcing natural geotextile with subgrade. The performance of laterite and clayey soil can be improved by adding non-woven geotextile reinforcement. When compared to their CBR values without reinforcement, California bearing ratio values are higher in the undisturbed condition, proving that the soil samples reinforced with non-woven geotextile meet the general requirements for subgrade soils established by the Federal Ministry of Works.

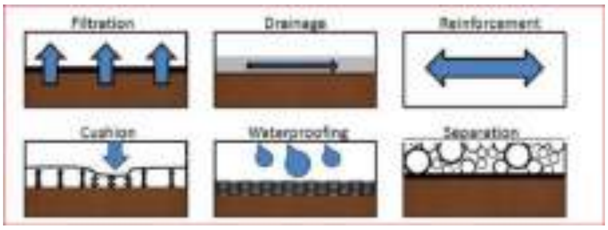


Fig. 6: Applications of geotextiles [61].

There are numerous applications for geotextiles in the construction industry.

(a) Separation

Two dissimilar materials, such as two soil layers with differing properties, can be isolated or separated using geotextiles, such as soil and pavement material [62]. It divides the various materials and keeps them from blending when a load is applied. It is possible to say that the geotextile's role is to keep pebbles from combining with the subgrade and breaking through the barrier [63]. The geotextile can also ensure that the coarse stone surface continues to have the ability to support loads. Geotextiles can differentiate between two floors with various geotechnical characteristics due to their continuity, flexibility, deformability, permeability, and high tensile strength without obstructing the flow of water in a natural way [64, 65].

(b) Filtration

Filtration is the stability of a geotextile-soil system that permits adequate liquid flow with negligible soil loss across the plane of the geotextile throughout the service lifetime appropriate for the application under consideration. Filtration's objective is to remove water while preventing the passage of fine particulates like soil. A filter placed behind the geotextile aids in achieving this [66]. Due to the equilibrium between the geotextile and soil system, sufficient liquid circulation and minimum soil loss are feasible across the whole surface of the geotextile.

The usage of a geotextile in a pavement trench drain is a typical example of how the filtration function is demonstrated. Under the conditions under consideration, the geosynthetic soil system ought to reach an equilibrium that permits adequate liquid movement [61]. Filtration refers to the cross-plane hydraulic conductivity or permittivity since liquid movement is perpendicular to the geosynthetic plane. AOS, which is defined as the opening size larger than 95% of the geotextile pores and is compared to the features of soil particle size, is another significant quality relevant to filtering. Eventually, the larger, coarser particles form a filtering bridge that traps the smaller, finer particles and builds a solid soil structure upstream [64].

(c) Drainage

Draining geotextiles requires fluid moving through the fabric's flat surface without causing soil loss. For the fluid flow process to perform as effectively as possible, the geotextile utilized for the drain function must be thick. Draining geotextiles requires fluid moving through the fabric's flat surface without causing soil loss. To ensure that the fluid passage procedure is as effective as possible, the geotextile utilized for the drain function needs to be thick [10].

(d) Reinforcement

Contrary to the common perception of soils as low-stress materials with high compressive strength, geotextiles are believed to have a bearing capacity or high tensile strength [67]. In order to maximize the efficiency of the soil and consequently the stability of the structural composition, geotextiles are the ideal material to use. It demonstrates how to use geotextiles for soil stabilization and consolidation to stop soil from collapsing [68]. As opposed to stabilization, where the bottom soil is strengthened, this application uses the geotextile as a source of strength. This is how the use of geotextiles for reinforcement is comparable to the use of other materials, such as concrete, for reinforcement. Thus, reinforcement applications are carried out by embedding the layer inside the weak layer rather than laying it on top of the layer that needs to be reinforced [69].

(Elshakankery et al., 2013) investigation into the benefits of using nonwoven polyester geotextiles to reinforce three different Egyptian soils. Five different geotextiles with weights ranging from 250 GSM to 600 GSM were evaluated. The soils are divided into three categories: hard, medium, and soft. The type of soil had a significant impact on the improvement of soil properties, with soft soil showing the largest increase in reinforcement ratio value, which advances from 1.07 for 250GSM to 33.38 for 600GSM geotextile[70]

The effects of nonwoven polypropylene geotextile on the unconfined compressive strength (UCS) and California bearing ratio (CBR) of clayey soil were examined by (Sivapragasam et al., 2010). Additionally, at 3 cm & 6 cm, 3 cm & 9 cm, and 6 cm & 9 cm from the top of the mould, respectively, geotextiles were positioned in single and double layers. When geotextile is placed 6 cm from the top in a single layer, the CBR and UCS values of virgin soil increase to 2.42% and 0.484N/mm2 from 1.37% and 0.285N/mm2, respectively. When using geotextile, the pavement's thickness requirement reduces from 74.22 cm for virgin soil to 54.91 cm [71]

P. B. Ullagaddi and T. K. Nagaraj state in their article "Investigation on Geosynthetic Reinforced Two Layered Soil System" that they used three different types of woven and nonwoven geotextiles with different physical and mechanical properties and varied configurations of the two soils, each with a different configuration of thickness. According to trial results, the CBR value is improving, which will increase bearing capacity. Pavement thickness is frequently decreased to perform even equivalent activities due to an enhancement in bearing capacity. The CBR value of woven geotextile was found to be higher than that of non-woven geotextile using U.S. Corps and IRC methods [72].

For the purpose of determining the subgrade modulus and boosting the bearing capacity ratio, Schriver et al. (2002) conducted an experimental investigation on lightweight aggregate beds reinforced with geogrid. According to the study, adding geogrid reinforcement to the subbase/aggregate interface effectively extends the lifespan of paved roads. At the interface between the asphalt and the aggregate and the aggregate and the subgrade, geogrid reinforcement offers a more uniform load distribution and a reduction in the maximum settlement [73]

When S.S. Bhosale and B.R. Kambale (2008) examined the data from the various sources used during this source search, they discovered that some research had been done on the use of geotextiles in flexible pavement for road construction. Small laboratory research has constituted the bulk of the work, and there is little information on extensive fieldwork or lengthy studies that have been published. Although there are numerous conventional design techniques for both flexible and rigid pavements, none of them include geotextiles. This study found that there exist design standards and methods for flexible paving road building that take geotextiles into account. Some of these processes will be described, but specifics are not provided in this paper and can be found in the corresponding sources. The most complete study on geosynthetic (geogrid or geotextile) use in base courses for flexible pavements is briefly summarised here, along with other geotextile usage-related topics that are thought to be crucial [74]

In a 2003 study, Ranadive looked into the effectiveness of geotextile reinforcement in soils other than sand, and in this work, model strip footing stress tests are performed on soil with and without single- and multi-layers of geotextile at various depths below the footing. The Universal Testing Machine was used for testing. According to the study, reinforced soil has a much higher bearing capacity than unreinforced soil. It was found that the BCR (Bearing Capacity Ratio) for a single layer system is maximum for a depth of layer below the footing equal to 0.25B, where B is the width of the footing, and BCR declines as the depth of layer grows. BCR for a constant d/B ratio and S/B ratio for multilayer systems, Ranadive, where S is the distance between succeeding geotextile reinforcing layers and d is the depth of a single reinforcing layer beneath the footing (assuming that the depth of the top layer beneath the footing is kept constant at 0.25B). The BCR is at its highest for N=4, although the percentage increase over N=3 is quite small. Therefore, N=3 is suggested as the ideal value [17].

Mayura M. Yeole, Twinkal P.Thakur, Yogita Gaurav, and Yash Agarwal (2018) discussed the article, which outlines the issue of soft soil and potential solutions. The study emphasizes the point that is reflected in the paper is the usage of geotextile as reinforcement in soil. The California bearing ratio test was run to examine how the behavior of the soil changed when geotextile was added or paired with it. They used the Modified Proctor Test on the soil with and without geotextile to determine the readings of the optimum moisture content and maximum dry density, which are 14.35% for pure soil and 11.38% for soil with geotextile. The CBR test methodology was thus finalized using the reading that was acquired. The tests that were run were for damp conditions that were taken at various times [75].

Noorzad et al. (2010) studied how geotextile reinforcement affected the soil's unconfined compressive strength (UCS) and shear strength parameters. The USC system categorized two soil samples as CL and CH (type I and type II), and two nonwoven geotextiles of 180GSM and 260GSM were employed. Between each layer of the geotextile, there was the same distance. It was shown that when the number of reinforcing layers increased, both types of soil's maximal strength values increased as well. Improvement was brought about by increasing cohesion in the case of soil I while not significantly changing the internal friction angle, and by increasing the internal friction angle while not significantly changing the cohesion value in the case of soil type II[59].

Jute geotextile's strength qualities were investigated by Bera et al. (2011) after it was stored in saturated soil. Six different types of woven jute geotextiles with the designations JG1, JG2, JG3, JG4, JG5, and JG6 are used, with corresponding mass per unit area values of 670, 560, 235, 800, 750, and 500GSM. Jute geotextiles are cut into suitable test sizes and buried for a period of 7, 14, 21, 28, and 45 days in various levels of saturated soil to determine their degrading characteristics. After 45 days of storage, the (JG6) jute geotextile's wide width tensile strength exhibits just a 10% drop in the cross-machine direction [76, 77].

Tuna et al., 2012 used a direct shear test to investigate the impact of mould size and the quantity of reinforcing layers on sand's shear strength parameters. Three nonwoven and two woven geotextile types out of five total types were employed. The two sand samples used were SP (poorly graded sand) and SW (well-graded sand). It was discovered that the reduction in shear strength following peak strength was significantly decreased in reinforced soils. As the mould size is reduced and the quantity of geotextile layers is increased, the cohesion and friction angle increase [39]. Geotextiles are now more regularly employed in the building of pavements since they have successfully served as engineering tools. Geotextiles are most typically employed in separation/stabilization during the building of both paved and unpaved roads. Geotextiles, whether used on paved or unpaved roadways, provide several of benefits including separation, stability, strengthening, and filtering. Natural gate materials for construction can frequently be replaced by geotextiles or used less frequently, which is both economical and environmentally friendly. The main problems mentioned in this study are widespread in road construction and have a number of sources. Infrastructure development in India must be completed as fast and affordably as feasible to fulfill the nation's current transportation needs. The dirt that was utilized to construct them has been linked to the majority of the failing roadways [77].

DA Ogundare et al 2018) When the two specimens of soil were reinforced with non-woven geotextile, their CBR values increased, rising from 4% and 7% to 15% and 21%, respectively, in the unsoaked condition. This shows that the non-woven geotextile-reinforced soil samples meet the requirements for sub-grade as set by the Federal Ministry of Works (1997) criteria for sub-grade soils [67].

Table 3: CBR result of with and without the geotextile [67].

Soil sample	Without non-woven geotextile		CBR value	With non-woven geotextile		CBR value
	2.5mm	5.0mm		2.5mm	5.0mm	
Sample A	3.6	4.0	4.0	14.3	14.9	15.0
Sample B	6.0	6.6	7.0	20.5	17.4	21.0

Using varying amounts of fly ash at 0%, 5%, 10%, 15%, & 20% and coconut coir at 0%, 0.25%, 0.5%, 0.75%, & 1%, Kumar et al. (2004) examined the unconfined compression strength and California bearing ratio on the black cotton soil. According to the study, 1% coconut coir and 20% fly ash added to black cotton soil improved the CBR value by 285% and the CBR value by 83%. Again, adding 20% fly ash to ordinary black cotton soil increased the unconfined compression strength value by 66%, and adding 20% fly ash and 1% coconut coir increased it by 120% [78].

E.A. Subaida et al. (2010) carried out an investigation to ascertain the advantages of replacing the reinforcing material in the pavement section with geotextiles made of manufactured coir. A strong circular plate in acres was used to apply monotonic, consistent stresses to both the laboratory-reinforced and unreinforced road sections. To examine the effects of estimated geotextile position and stiffness, dual base courses and two kinds of woven coir geotextiles were used [77].

Sugandini and Madhuri (2017) investigated the interactions between soil geo-synthetics, such as geotextiles, and four different types of soil: red laterite, marine clay, black cotton soil, and sandy soils. The mechanical strength of the sub-grade soil and the densities of the soil samples were assessed using CBR tests.

The main objective of the work is to investigate the effects of soil strength following the application of geosynthetics [79].

Jute geotextile was used in Pavaniet's investigation of subgrade soil in the Prakasam area of Andhra Pradesh. In this article, jute fibre is employed in the strengthening of the soil layers in the design of pavement. Numerous field case studies revealed that after being buried in soil for about 18 months, the strength of jute geotextile frequently decreased by 60 to 70 percent. The study uses jute, a biodegradable material, to fortify the soil layer, measure structural stresses and strains under typical axle load circumstances, and prolong the life of the JGT by bituminous coating it. Using polythene sheets as a sandwich layer is another technique used to boost the strength and span of jute fiber and the sub-grade strength of CBR value. The CBR value of sub-grade soil will be studied to see if bitumen-coated/polythene sheets made of jute may increase it. On clay soil (CI), some experimental experiments have been done, but the findings were unreliable for significant compaction. JGT's primary use is to thin out pavement layers, and properly engineered woven JGT laid on a road's subgrade improves the road's bearing capacity (stated as CBR %). The phenomena is the outcome of the filtering and separation tasks carried out by a woven JGT set on the subgrade with the proper design [80].

(2016) Pavani et al. investigated the utility of jute Geotextile. It was discovered that the number of jute geotextile layers added to the soil raised its CBR value. For jute covered in polythene sheet and jute sprayed with bitumen, a maximum improvement of 300% in CBR was attained. It is evident that jute geotextile can be used as a separating layer and reinforcing material when building roads with moderate traffic volumes. When bitumen-coated jute is used, the pavement thickness could be lowered by 234mm, and when polythene sheets are utilized, it could be reduced by 208mm [81].

Tanvi Singh et al.'s (2020) study examined the effects of reinforcing single and double layers of woven and non-woven geotextiles at varying depths of reinforcement on CBR value. Additionally, ANN and M5P modeling methodologies were applied for CBR prediction. The following is a list of their research's key findings: When subgrade soil was reinforced with woven and non-woven geotextiles, its strength increased rise in strength compared to the parent soil was seen that ranged from 19.79% to 188.23% depending on the positioning of the reinforcement, the type of geotextile utilised, and the number of layers used for reinforcement [82].

For both single and dual layers, and for all reinforcement places, sub-grade soil reinforced with woven geotextile produces superior results than that reinforced with nonwoven geotextile. To maximize the benefits of reinforcement, the geotextile layer's reinforcement must be placed at M/3 and M/2 with both woven and non-woven geotextiles. For both woven and non-woven reinforcement, the increased ratio of the double layer was larger than that of the corresponding single layer. M5P performed better than ANN at predicting the woven CBR value. ANN performed better than M5P at predicting the non-woven CBR value [82].

Jute-HDPE (hybrid) woven geotextile's effects on rural unpaved roads' CBR value and rut depth were examined by (Basu et al., 2009). After 18 months, it was discovered that roads using hybrid geotextiles had smooth surfaces free of significant signs of rutting or subsidence, but roads without geotextiles had 5- to 35-mm-deep ruts that were evident. The field CBR test conducted after periods of 11 and 18 months also demonstrated a noticeable improvement, with enhancements in the strength of 67% and 73%, respectively, utilizing hybrid geotextile [83].

(Rawal et al., 2011) examined the characteristics of nonwoven hybrid geotextiles with weight ratios of 0%, 20%, 40%, 60%, 80%, and 100% constructed of polyester/viscose and polypropylene/viscose fibres. These geotextiles had 200GSM and 400GSM. Tensile strength and puncture resistance tests were performed, and it was discovered that the hybrid geotextile's strengths and puncture resistance values are comparable to those of synthetic geotextiles and, in some cases, even exceed them. Thus, it may be inferred that viscose, a type of cellulosic fiber, can be utilized successfully with synthetic fibers to stabilize soil [84].

Prof. Mayura Yeole and Dr. J.R. Patil performed a CBR test in the lab on granular soil with or without geotextile that was kept in one or two layers in the mould. California Bearing Ratio increased when the geotextile was placed in two layers at (25 & 75 mm), (50 & 75 mm), and (50 & 100 mm), In comparison to the California Bearing Ratio of no geotextile, reaching its highest level at 25 and 75 mm geotextile layer by 38.21%. A single layer of geotextile was placed at a depth of (25, 50, and 100mm) from the top of the mould [85]

3. Conclusions

From the different studies, it shows that using geosynthetic reinforcement can enhance the soil’s engineering character. Geogrid is used to strengthen weak soils, increasing their strength. Due to its durability and lack of biodegradability, it also extends the pavement's useful life. Therefore, the usage of Geogrid should be promoted as an efficient and cutting-edge method of enhancing road building on subpar subgrade materials. Geotechnical engineers were attracted to the research on reinforced soil because it may be used to overcome a variety of geotechnical and transportation engineering challenges. The CBR value created after geogrid is higher than that of untreated soil, according to all of the papers cited above. It decreases the pavement layer thickness.

In terms of performance under dynamic loadings, geotextile-reinforced soils outperform conventional soil. It extends the pavement's service life and is both durable and non-biodegradable. The soil's characteristics can be improved and the subgrade layer thickness can be decreased by placing the geotextile between the subgrade layer and the ground surface. The cost of building the road as a whole has been significantly reduced because of the use of geotextile. The use of geotextiles has an impact on all phases of road construction, from base course preparation to subgrade preparation. More research in this field is necessary to comprehend the workings of geosynthetics better.

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