

# A Review Paper on ‘Stabilization of Subgrade Using Bitumen, Steel Slag and Geogrid’

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**ABSTRACT:** Soil is used sub base and base material, if strength of soil is poor, then stabilization is normally needed. Subgrade is sometimes stabilized or replaced with stronger soil. Soil could be black cotton or as fly ash which could fly in contact with air. There are numerous stabilizers used for stabilizing the soil such as lime, cement, bitumen, fly ash etc., in this paper bitumen as stabilizer. Bitumen emulsion is costly material in road construction. So its amount play crucial part to stabilize the soil. It increases the stability of soil mechanically. It does not react with soil. It is just fill the pores of soil. Soil stabilization is the process of improving the shear strength parameters of soil and thus increasing the bearing capacity of soil. It is required when the soil available for construction is not suitable to carry structural load. Soils exhibit generally undesirable engineering properties. Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soil stabilization is used to reduce permeability and compressibility of the soil mass in earth structures and to increase its shear strength. The main objective of this paper is to review the effect of bitumen and steel slag on soil stabilization.

**KEYWORDS:** Soil Stabilization, Shear Strength, Stability, shrink, swell, Steel Slag, Bitumen, etc

## I. INTRODUCTION

Soil stabilization may be defined as the alteration or preservation of one or more soil properties to improve the engineering characteristics and performance of a soil. Stabilization, in a broad sense, incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. Soil stabilization refers to the procedure in which a special soil, cementing material, or other chemical materials are added to a natural soil to improve one or more of its properties. One may achieve stabilization by mechanically mixing the natural soil and stabilizing material together so as to achieve a homogeneous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting it permeate through soil voids.

The prime objective of soil stabilization is to improve the California Bearing Ratio of in-situ soils by 4 to 6 times. The other prime objective of soil stabilization is to improve on-site materials to create a solid and strong sub-base and base courses. In certain regions of the world, typically developing countries and now more frequently in developed countries, soil stabilization is being used to construct the entire road. The soil in subgrade is normally stressed to certain minimum level of stresses due to the traffic loads. Subgrade soil should be of good quality and appropriately compacted so as to utilize its full strength to withstand the stresses due to traffic loads for a particular pavement. This leads the economic condition for overall pavement thickness. On the other hand the subgrade soil is characterized for its strength for the purpose of design of any pavement.

Improvement of soil engineering properties is referred to soil stabilization. There are two primary methods of soil stabilization. One is mechanical method and the other one is chemical or additive methods. Soil is a gathering or store of earth material, determined regularly from the breakdown of rocks or rot of undergrowth that could be uncovered promptly with force supplies in the field or disintegrated by delicate reflex means in the lab. The supporting soil beneath pavement and its exceptional under course is called sub grade soil. Without interruption soil underneath the

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Vol. 8, Issue 2, February 2019

pavement is called regular sub grade. Compacted sub grade is the soil compacted by inhibited development of distinctive sorts of substantial compactors.

Geosynthetics are widely used for separation, protection, drainage, filtration and sealing. In addition, high-strength geogrids have been more and more successfully used in recent times for the construction of steep slopes and geogrid reinforced bridge abutments, the crossing of areas with soft soil by using geosynthetic encased sand columns and the bridging of areas susceptible to sinkholes. One of the most widely spread applications is the stabilization of a base course above soft ground. The effect of the use of a geogrids combined with a nonwoven. It is obvious that the cost for maintaining an unreinforced side road over a long period can easily exceeds the relative small investment of an additional geogrid layer.

## II. RELATED WORK

### 1.Bitumen

Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. Bituminous materials consists of bitumen which is a black or dark coloured solid or viscous cementitious substances consists chiefly high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar.

### 2. Steel Slag

'Iron' from ores is a complex process requiring a number of other materials which are added as flux or catalysts. After making steel these ingredients forming a matrix are to be periodically cleaned up. Removed in bulk, it is known as steel slag. For industrial use, different grades of steel are required. With varying grades of steel produced, the resulting slag also assume various characteristics and hence strength properties. Grades of steel are classified from high to medium and low depending on their carbon content. Higher grades of steel have higher carbon contents. Steel slag's are the byproducts of the companies which are very cost low for that we can make them as the additional sources for the pavements to use as the ingredients of the constructional materials. They are obtained by the de oxidation of the products of cast iron in the industrial usage. They are the byproducts of the companies making them economical in the construction practice.

### 3. Geogrid

A geogrid is geosynthetic material used to reinforce soils and similar materials. Geogrids are commonly used to reinforce retaining walls, as well as sub-bases or subsoils below roads or structures. Soils pull apart under tension. Compared to soil, geogrid are strong in tension. This fact allows them to transfer forces to a larger area of soil than would otherwise be the case. Geogrids are commonly made of polymer materials, such as polyester, polyvinyl alcohol, polyethylene or polypropylene. They may be woven or knitted from yarns, heat-welded from strips of material or produced by punching a regular pattern of holes in sheets of material, then stretched into a grid.

## III.LITERATURE REVIEW

**Shubham Langar et al. (2018)<sup>1</sup>** studied on Enhancement of Shear Strength of Soil Using Bitumen, in this study he disused that to improve the properties of the gravelly soil by adding bitumen emulsion as stabilizing agent and little bit cement as filler. An attempt has been made to use emulsion for improving the strength and geotechnical properties of gravel soil. Very mostly, use of use of bitumen emulsion is environmentally accepted. To achieve the whole project some experimental investigation is needed in laboratory. The experiments which to be conducted are Specific Gravity of the soil sample, Grain size Distribution of soil sample and liquid limit plastic limit test to identify the material and Standard Proctor test to obtain maximum dry density and optimum moisture content of soil sample, Unconfined shear strength test of soil sample mixing with emulsion.

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**Olumide Moses Ogundipe(2014)<sup>2</sup>** had proposed about strength and compaction characteristics of bitumen-stabilized granular soil. In his study, he was discussed about the investigation of the stabilization of granular soil with bitumen. The strength and compaction characteristics of the natural and stabilized granular soil were determined. The relationship between the optimum moisture content and the bitumen content showed that the moisture content in the soil must be considered in the selection of the binder content that will give the best results. Generally, he was found that the properties of the granular soil improved when stabilized with cutback bitumen.

**R. Deby Linsha et al. (2016)<sup>3</sup>** proposed about performance evaluation of improvement of shear strength of soil using bitumen emulsion the strength of soil is increased by adding bituminous emulsion instead of replacing with stronger soil. The initial strength of the soil is determined by conducting soil tests such as sieve analysis, plastic limit, liquid limit, shrinkage limit, Modified proctor compaction test and California bearing ratio tests. Test result indicate that with the increase of bitumen emulsion in the soil sample till 10% proportion ratio the soil strength is increased and after certain percentages ( 20% and 30%) its getting decrease. The results are shown that the strength of the soil is good when 10 % bitumen emulsion is added.

**Paul et al. (2011)<sup>4</sup>** suggested an introduction to soil stabilization in pavement taking a mixture of bitumen and well-graded gravel or crushed aggregate. After compaction it gave an exceedingly steady waterproof mass of sub base or base course quality. The fundamental system involved in asphalt stabilization of fine-grained soils is a waterproofing wonder. Soil particles or soil agglomerates were covered with asphalt that forestalls or abates the entrance of water which could regularly bring about abatement in soil quality. What's more, asphalt stabilization can enhance durability qualities by making the soil impervious to the unfavorable impacts of water, for example, volume. In non-iron materials, for example, sands and gravel, pounded gravel, and smashed stone, two fundamental systems are dynamic: waterproofing and adhesion. The asphalt coating on the union less materials gives a film which anticipates or hinders the entrance of water; subsequently reducing the inclination of the material to lose quality in the vicinity of water. The second instrument had been distinguished as adhesion and characteristics of gravelly soils.

**Martin et al. (2009)<sup>5</sup>** developed a paper deals with foam bitumen stabilization. Foamed bitumen is a mixture of bitumen, air and water. Here 2 percent of cement and 3.5 percent of bitumen foam was used. From here it has been found that Rehabilitation using foamed bitumen had proved to be successful because of its ease and speed of construction, its compatibility with a wide range of aggregate types and its relative immunity to the effects of weather.

**Yuehuan et al. (2010)<sup>6</sup>** worked on foamed bitumen stabilization for Western Australian pavements. Currently, the popularity of soil cement stabilization had been challenged by anew innovative soil improvement technique, known as foamed bitumen stabilization. Very few of work have been done on it and application of this type of stabilization is currently applied in flexible pavement subgrade stabilization. Numerous Australian roadway and way offices have committed noteworthy investigation and stores to investigate this system so as to attain a more adaptable and weakness safe balanced out material suitable for an extensive variety of pavement conditions. Percent of froth bitumen utilized as 3 to 5 percent. It was one kind of mix design however here after the mix design process stabilization done and CBR quality tried.

**Satyendra kumar verma (2015)<sup>7</sup>** directed a test research on a laboratory study on use of bitumen emulsion in black soil. The whole laboratory work revolves around the basic properties of soil and its strength in terms of CBR. A little cement added to provide better soil strength. It is observed that excellent soil strength results by using cationic bitumen emulsion (CMS) with little quantity of cement used as filler. The appropriate mixing conditions for black soil with CMS Bitumen emulsion have been attempted. Here we use ideal soil of passing 600 microns IS Sieve. There is a considerable improvement in California Bearing Ratio (CBR) of subgrade due to use of bitumen emulsion if proper mixing is done.

**V. Shashank, et al (2017)<sup>8</sup>** studied on application of steel slag as an effective construction material in pavements. He was found that, the powdered steel slag acts as a good binding material in the pavements. The steel slag is replacing the

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Vol. 8, Issue 2, February 2019

aggregates for about 20-30%, hence this makes the construction as an economical construction. Since steel slag is a waste product of the major industries it can be obtained for lower cost. Steel slag is giving more strength than the traditional construction pavement process and for an effective low cost product.

**Chippada Srinivas (2017)<sup>9</sup>** carried out an excellent work to establish the experimental investigation on expansive soil stabilization by using steel slag. He conclude that Steel slag is a by product of steel manufacturing industry which is dumped in large quantities every year. It is desirable to partially replace expansive soil with steel slag. In his research work, expansive soil is partially replaced with steel slag at different percentages. Tests like plastic limit, liquid limit, standard proctor and California bearing ratio have been conducted to derive such optimum percentage of steel slag in expansive soil. Liquid and Plastic limits increased with increase in steel slag content in clay soil. Optimum Moisture Content had varied randomly with increase in Steel Slag content in clay soil heavy weight compaction. Maximum Dry Density increased with increase in Steel Slag content in clay soil. CBR Penetration resistance had varied randomly with increase in Steel Slag content in clay soil. The optimum percentage of pulverized Steel Slag in clay soil is up to 20%. Steel Slag can be effectively mixed in Expansive type of soils to improve engineering properties.

**Saurabh Kumar et al. (2016)<sup>10</sup>** concentrated on the stabilization of clayey soil using steel slag. In his project, strength characteristics of clayey soil with steel slag have been studied. With the addition of slag percentage in the soil the maximum dry density in increasing order and the optimum moisture content start decreasing at both slag passed through 180  $\mu$  and 300  $\mu$  sieves. The MDD result shows the increasing trend for soil slag mixture and OMC results shows the decreasing trend for soil slag mixture. In UCS, the unconfined compressive strength of soil slag mixture having increasing trend. There are many factors like gradation, carbon content, iron content and fineness etc., mainly control the Strength of soil treated with steel slag. Samples are fails by vertical cracks and sudden failure. The result of Plastic Limit increases at up to 8% of steel slag mixture with parent soil and start decreasing after 8% of steel slag mixture. And Liquid Limit results start decreasing for steel slag mixture with parent soil. Due to friction between particles of steel slag, Liquid Limit result has been decreasing. Plasticity index is in reducing manner for slag passed through 180  $\mu$  and 300  $\mu$  sieves.

**Dr. B. M. Patil (2018)<sup>11</sup>** directed a test research on effect of steel slag on CBR value of black cotton soil. The evaluate effect of addition of steel slag with various percentages to stabilize the black cotton soil and to verify its suitability to be used as a construction material for road, embankment and structural fills. Their study has been conducted to assess the potential of the steel slag to stabilize the Black cotton soil. BC soil was mixed with the various percentage of steel slag (5, 10 and 15%). Performance of the black cotton soil is evaluated experimentally by CBR test. The results of CBR for plain BC soil and sample mix with the various percentage of BC soil indicates that, the use of slag significantly improved and strengthened the properties of BC soil in which it was poor. There is significant reduction in swelling behavior of soil.

**Kavitha S. Nair et al (2017)<sup>12</sup>** studied on improvement of soft subgrade using geogrid reinforcement and conclude that the CBR value improved by 50.06 % for treated geogrid reinforcement than untreated geogrid, when the geogrid is placed at 0.2 H from the top of the specimen in unsoaked condition. Multiple layer reinforcement achieves greater strength than single layer. Optimum value is obtained when geogrid is placed in multiple layers at 0.2H and 0.4H from top of the specimen by providing the benefit of better load distribution. Thus treated geogrid at multiple layer should be used for reinforcement to achieve maximum strength with long term durability. CBR value decreases at soaked condition for both treated and untreated geogrid placement. At soaked condition, CBR value increased for treated geogrid by 50.07% than untreated geogrid when placed at 0.2 H from top of the specimen.

**Olaniyan O. S at al (2012)<sup>13</sup>** experimental studied on reinforcement of subgrade soils with the use of geogrid, his study investigated the application of geogrid to subgrade material as a form of reinforcement to road construction. The geogrid considerably increases the strength of poor soils, which is reflected in the higher CBR values. His study shows that the strength of the subgrade is significantly altered positively by the positioning of the geo-grid at varying depth. He was observed that the highest subgrade strength is achieved when it is placed at 3/5H for a single layer although has

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Vol. 8, Issue 2, February 2019

satisfactory result at 2/5H and 4/5H respectively. On reinforcing the soil, there is considerable increase in performance of the subgrade in the unsoaked condition. The use of geogrid as reinforcement to poor soils improves its strength. It is non-bio degradable and therefore durable; it also increases the ultimate service life of the pavement. The use of Geogrids should therefore be encouraged as an effective and modern form of improving road construction on poor sub-grade materials. Further research should be analyzed in ascertaining the effect of geogrid on subgrade soils under unsoaked condition.

## IV. SUMMARY

Various types of steel slag and bitumen emulsion can be used as a stabilization of material in different soil types for improving the CBR value of the soil. Following table summarizes several previous researches about the effect of steel slag and bitumen emulsion on stabilization of soil.

Table 1. Summary of Previous Research Studies on effect of steel slag and bitumen emulsion on soil.

SR.N O.	NAME OF AUTHER	TYPE OF MATERIAL	CONCLUSION
1	Shubham Langar et al. (2018)	Bitumen Emulsion	Improving the strength and geotechnical properties of gravel soil.
2	Olumide Moses Ogundipe (2014)	Cutback bitumen.	The properties of the granular soil improved when stabilized with cutback bitumen.
3	R. Deby Linsha et al. (2016)	Bitumen Emulsion	The strength of the soil is good when 10 % bitumen emulsion is added.
4	Paul et al. (2011)	Asphalt	Improve the strength of granular soil
5	Martin et al. (2009)	Foamed Bitumen	Rehabilitation using foamed bitumen had proved to be successful
6	Yuehuan et al. (2010)	Foamed Bitumen	CBR value is increases
7	Satyendra kumar verma (2015)	Bitumen Emulsion	Improvement in California Bearing Ratio (CBR) of subgrade due to use of bitumen emulsion
8	V. Shashank et al (2017)	Steel Slag	Steel slag is giving more strength than the traditional construction pavement process.
9	Chippada Srinivas (2017)	Steel Slag	Slag can be effectively mixed in Expansive type of soils to improve engineering properties.
10	Saurabh Kumar et al. (2016)	Steel Slag	Unconfined Compressive Strength of soil slag mixture having increasing
11	Dr. B. M. Patil (2018)	Steel Slag	It is significant reduction in swelling behavior of soil
12	Kavitha S. Nair et al (2017)	Geogrid	CBR value increased for treated geogrid by 50.07% than untreated geogrid when placed at 0.2 H from top of the specimen.
13	Olaniyan, O. S. et al (2012)	Geogrid	geo-grids placed at 3/5 the distance from the base showed higher CBR value.



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Vol. 8, Issue 2, February 2019

## V. DISCUSSION

Subgrade may be defined as a compacted soil layer, generally of naturally occurring local soil, assumed to be 300 mm in thickness, just below of the pavement crust. It provides a suitable foundation for the pavement. So it is very important to improve strength of subgrade soil, it may be by replacing good soil or by stabilization of existing soil. To check the subgrade soil stability CBR test is very commonly used test.

Bituminous soil stabilization refers to a process by which a controlled amount of bituminous material is thoroughly mixed with an existing soil or aggregate material to form a stable base or wearing surface. Bitumen increases the cohesion and load-bearing capacity of the soil and renders it resistant to the action of water. Bitumen stabilization accomplished by using asphalt cement, asphalt cutback or asphalt emulsions. The type of bitumen to be used depends on the type of soil to be stabilized, method of construction and weather conditions. In frost areas, the use of tar as binder must be avoided because of its high temperature maximum susceptibility. Asphalts and tars are bituminous materials which are used for stabilization of soil, generally for pavement construction. Bituminous materials when added to a soil, it imparts both cohesion and reduced water absorption.

The application of geogrid to subgrade material as a form of reinforcement to road construction. The geo-grid considerably increases the strength of poor soils, which is reflected in the higher CBR values. The use of geogrid as reinforcement to poor soils improves its strength. It is non-bio degradable and therefore durable; it also increases the ultimate service life of the pavement. The use of Geogrids should therefore be encouraged as an effective and modern form of improving road construction on poor sub-grade materials. Further research should be analyzed in ascertaining the effect of geogrid on subgrade soils under unsoaked condition.

## VI. CONCLUSION

From the above research work done by different researchers, the following conclusions are drawn:

1. The considerable improvement in California Bearing Ratio of sub-grade due to use of bitumen mixture if proper mixing is done.
2. It has been seen that the best results are obtained if the soil emulsion mix is left for about five and half hours after mixing.
3. As we increase the amount of mixture California Bearing Ratio value of soil is increases. But the cost of mixture is so high so the amount of mixture also depends upon budget and importance of structure.
4. The use of steel slag on soil shows an effective use. Steel slag can be used as an additive for the stabilization of soil.
5. According to study, it shows that due to the addition of steel waste the maximum dry density increases and the optimum moisture content decreases.
6. In geotechnical engineering applications steel slag may be feasible. By the addition of steel slag in the poorly graded soil may improve the bearing capacity of soil. Also by using waste as a admixture it can reduce the cost of stabilization process and also due to use of waste it do not affect the environment.
7. The CBR value improved by treated geogrid reinforcement than untreated geogrid, when the geogrid is placed at 0.2 H from the top of the specimen in unsoaked condition.
8. Multiple layer reinforcement achieves greater strength than single layer.
9. As technology advances and economic conditions change, many more materials will be introduced into subgrade to improve their compact ability, durability, and strength. At the same time, more performance-based testing will be necessary to prove the effectiveness of these stabilization agents.

## VII. FUTURE WORK

From the above literature review I found that, the combination of two or more waste materials cannot be used yet. So, for further experimental work the combination of bitumen emulsion and steel slag will be used. The optimum percentage of both bitumen emulsion and steel slag mix together with soil and this stabilised soil will be used with geogrid.

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Vol. 8, Issue 2, February 2019

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