

Comparative Study of Expansive Sub-Grade Stabilization using Industrial Wastes like Foundry Sand, Quarry Dust, Demolition Wastes and Rubber Scrap

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Abstract

Searching for the best stabilizer to solve problems in the presence of expansive soils is still a top priority, “not only to accomplish the requisite soil engineering qualities but also to meet the project's cost efficiency. Based on experimental studies, the major goal of this paper was to review the materials and methods that have been used to stabilize the Expansive soil. Various materials were investigated, including industrial granite refuse, demolition debris, quarry dust, and foundry waste sand.

The usefulness of these materials as soil stabilizers is determined solely by experimental results in terms of strength, as determined by California Bearing Ratio (CBR) tests and shear testing. Expansive soil's engineering qualities were improved in comparison, and these materials have the potential to be used as a soil stabilizer in construction operations while also being cost effective.

Keywords: *Expansive soil, soil stabilization, admixture, California Bearing Ratio (CBR), and plasticity are some of the terms used in this study.*

1. Introduction

For a developing country like India, roads are critical for the growth of financial activities. The design and building procedures have a significant impact on the road's durability. Sub-grade is often made out of locally available normal soils. The pavement's

performance is determined by the qualities of the sub-grade soil. In the event of filling, the soil must be determined based on the appropriate qualities in order to avoid transportation costs. Since clay soil qualities change dramatically when it comes into contact with water. When clay soils come into touch with water, their volume changes, potentially causing damage to flexible pavements. When the expansive clayey spoils come into touch with water, the volume expands and shrinks alternately over the dry period.

Unsuitable soil for sub-grade in flexible pavement construction is soil that fails owing to shear, crushing, or severe settlement. In these circumstances, changing the sub-grade soil is not recommended because it is both costly and inconvenient. In such instances, soil stabilization is a technique that has been applied. Stabilization is a technique for improving the properties of native soil or granular material used in pavement layer building.

The values of G^* and for asphalt binder are highly dependent on the test temperature and frequency of loading”. G^* is a measure of the total resistance of a material to deformation when exposed to a sinusoidal shear stress load. G^* consists of both elastic and viscous components. “The δ is an indicator of the relative amounts of viscous and elastic elements. The DSR used investigates the rheological properties of $CaCO_3$ and Al_2O_3 nanoparticles modified asphalt binders using a frequency sweep test.

2. Objective

Where the filling materials or existing soil do not have the specified qualities, appropriate stabilization measures are recommended to improve the behavior. Proportioning technique, cementing agents, modifying agents, moisture or waterproofing agents, heat treatment, water retention agents, chemical stabilization, and mechanical stabilization are some of the procedures that can be used to stabilize the sub-grade. We can establish viable properties in the soil by adding non-hazardous inert industrial wastes like Foundry Sand, Quarry Dust, Demolition Wastes, and Rubber Scrap. The use of discarded tyre scraps with unique features such as flexibility, strength, and resilience is effective in soil stabilization. Even the surrounding environment is protected from the use of chopped rubber material in sub grade soil.

Aquifer water quality parameters are not affected during the infiltration of rain water through Sub grade, the recent analysis proves that. The main principle of this technique is proportioning the admixture content and mechanical compaction.

The effects that may take place in the clayey sub-grade due to stabilization are as follows:

1. Strength achievement referred in terms of test values such as CBR or shear strength test value.
2. Reduction in Optimum Moisture content and cohesion.
3. The physical changes may be listed as density and stiffness due to the change in soil texture. The resulting textural changes lead to decrease in Plasticity Index.
4. Swelling and shrinkage effects of the base soil may be brought in control with the addition of stabilizer, since the placement of inert particles creates discontinuity in clayey medium. So, the mutual attraction (shrinkage) and repulsion (Swelling) between the clay particles goes down.
5. Adding of shredded rubber tyre varying the different proportion as well as the aspect ratio gives the control on soil property. This shredded rubber scraps introduces adhesion between the clay and scraps and increase the tensile capacity of soil at the weak planes even though rubber

scraps are not lengthy considerably .

Sub-grade stabilization improves the structural integrity of flexible pavement in overall. Hence the unsuitable Expansive soil becomes feasible sub grade strata for flexible pavement after the additions of any one of the inert admixtures. Economical aspect in construction of the flexible pavement is also maintained.

Enhancement of Expansive sub-grade by applying lime, Portland cement, and diverse synthetic mixes is an effective method. On the other hand, consuming these additives could raise the total cost. However, using industrial by-products in the enhancement of poor soil is common as it preserves the environment and reduces the expense.

3. Literature Review:

Foundry Sand

Prashant Kumar et al. (2016): Effect of Foundry Sand on expansive soil was studied and experimented by Prashant Kumar, Prof. M.C.Paliwal, Prof. A.K.Jain; the approach has mainly concentrated on usage of Foundry sand as admixture. Foundry sand waste requires 10% OMC for the maximum compaction this low water consumption reflects it is non cohesive. It can reduce the cohesion of virgin soil by adding of foundry waste which is a non-cohesive material. By 20% and further addition of foundry sand waste shows an increase in angle of internal friction between the particles. The CBR value of the soil improved from 8.9 to 18.21 with increasing percentage of foundrywaste. Shearing resistance angle of the soil increased from 22 to 28 by adding foundry waste. Finally it is observed that foundry waste sand is a very good material for strength improvement.

2.1.2. Amrullah Abdul Rahim Zai et al. (2020): Effect of Foundry Sand, Glass fiber and Fly ash on expansive soil was studied and experimented; Result shows that fine foundry sand can be selected for soil stabilization since it has high silica. Expansive soil shows MDD with 20% addition of foundry sand by weight. CBR value increases with the percentage

addition of foundry sand and glass fiber. Glass fiber increases CBR and MDD with the peak influence show at (1.2 to 1.6) %. Optimal Maximum dry density achieved by addition of 40% of foundry sand and CBR value increase from (2.44% to 5.1%). it shows significantly increase with the utilization of foundry sand and fly ash in clayey soil.

Quarry Dust

U Arun Kumar, Kiran B. Biradar (2013): Effect of granite dust on expansive soil was studied and experimented; the approach has mainly concentrated on usage of waste materials as a soil stabilizer. In this study Quarry Dust was selected as a Stabilizer. Previous research has identified the granite dust manifest high shear strength [8][11]. Mixing the crusher stone dust with lime has reduced the swelling of the clay soil. Amongst the various properties, California Bearing Ratio (CBR) was the main concern as the study influences the sub-grade soil stabilizer. Quarry dust addition to the soil reduces the cohesion value, reduces the Liquid limit and plasticity index. OMC is reduced with increasing the percentage addition and MDD increased by 5.88% by adding 40% of Quarry dust. Higher CBR value also gained with 40% addition of QD in Expansive soil.

Naman Agarwal (2015): In this study researcher used stone dust as soil admixture to improve the characteristics of expansive soil. Basic strength tests and index properties were analyzed on virgin and treated soils in the laboratory on stone dust added expansive clays. Adding stone dust to Black Cotton soil decreases the OMC and increases Maximum Dry Density; addition of 30% stone dust in the soil shows optimum results. The CBR value increased by 50% of the sample concern.

Ahmed Salama Eltwat and Fares Tarhuni (2020): In their study on using granite industry dust as a soil admixture to improve the characteristics of expansive soil. Granite dust as powder added with varying percentage 4%, 8%, 12%, 16%, and 20%. Basic strength tests and index properties were analyzed on virgin and treated soils. Result shows that addition of granite dust increases the shear strength, CBR and Maximum dry density

(Compaction property). 8% granite dust addition to the sample found as the optimal percentage in order to improve the CBR Value.

Ayushi D. Panchal: Researchers conducted the laboratory experiment on the virgin soil and observed 20.18% as shrinkage limit and 90% as swell index. While replacing the 10 % of Black cotton soil, liquid limit value reduced to 38 % from 54 %. Plasticity index reduced to 12.35% from 28.37% and the moisture content reduced to 20.32 %. Maximum improvement on CBR from 11.53% to 15.28% is achieved at 10% replacement of soil with quarry dust.

Demolition waste:

Vivek S and Primal Kumar (2018): Researchers conducted the laboratory experiment on demolition waste added expansive soil. They have taken concrete debris, bricks and plastering pieces as the major additives from Trichy with size around 2.36mm. Building demolished waste is added as percentages from 5, 10, 15 and 20. They got good results with 5% of building demolished waste and 7.5% of water addition on MDD. They have done the same procedure on saw dust. With 15% of combustion of saw dust and 7.5% of water good maximum dry density was achieved.

Anand Kumar B.G.(2014): Various tests were conducted on demolished brick waste (DBW), virgin soil also on Soil-DBW mixes of various proportions to evaluate the basic properties. Optimum DBW content was found to be 40 % based on standard compaction test. California bearing ratio (CBR) and Unconfined compressive strength (UCS) values for 40% blending showed the highest values as compared to other proportions. It was observed that for virgin soil CBR values of 2.5 mm and 5 mm penetration were 2.69 and 2.43, and blending with optimum dosage of 40 % DBW resulted in CBR values of 2.5 mm and 5 mm penetration 13.86 and 13.10. These values clearly indicated that an increase of approximately over 400 % in CBR values with 40 % DBW mixed with cohesive soil as compared to virgin soil”.

“Rubber Tyre Scrap

Nilesh Agawane (2019): Shredded rubber tube in the proper aspect ratio (10mm in width and 20mm) are used to improve properties of expansive soil. Varying the addition percentage from 5%, 10%, and 15% the laboratory works had conducted on parent soil. With 10 percent addition of shredded rubber tubes CBR value increased from 7% to 7.73 %. But the 15% addition leads to the drawdown.

Sanjeev Singh (2017): A study was carried out by Sanjeev Singh on the effect of rubber tyre scrap as a stabilizing agent for the sub-grade layer in construction of pavement. Authors advised to use rubber tyre scrap as a stabilization material since it doesn't has any adverse effect to the environment. Varying the percentage of shredded tyre scrap increase in UCC value is noted. Shredded tyre materials especially selected in the range in between the 425 microns to 600 microns. 18% of this material addition in soil improved the UCS value to 1.75kg/cm². But it is observed by them that the varying the aspect ratio of the material added and increase in percentage addition leads to drop in strength properties.

4. Discussion:

Because the CBR Value of the sub grade and the traffic circumstances (CSA – Cumulative Standard Axles) during the design life are so significant, the stability of the sub grade soil is crucial. If the CBR value of the sub grade is low, stabilization by adding eco-friendly admixtures to the existing soil is a viable option for increasing the CBR value. It should be noted that the increase in CBR value varies by material; the CBR value does not always increase with the addition of these materials; there is an optimal limit. The major control in proportioning the admixtures with respect to the existing soil mass might be achieving the probable target CBR or density.

Mix in Place Method is the Easy and better option for the thorough mixing of admixture with the soil and need to be monitored on the pulverization of filling expansive soil.

Foundry sand

- A Low compressible cohesive soil can be improved as much as possible. We can double the value of CBR of the expansive soil with addition of 20% of Foundry sand by weight. So, target CBR can be achieved with respect to with proportioning of FS max of 20% (CBR initial value to double the value)
- Plasticity of soil has reduced considerably
- Cohesiveness of the mixed sample comes down by 50 kpa with addition of 20% of FS.
- 6 to 10 tonnes of Foundry sand has been produced every year in India

Quarry Dust

- For Highly Compressible soil, the optimal addition of QD is limited with 10%, beyond which CBR value comes down. At 10% addition in CH, 30% of CBR can be increased.
- For Low Compressible soil, when QD is added upto 30 % , the CBR value can be increased upto 50%
- 20 Mega tonnes of Quarry dust has been produced every year in India

Demolition Waste

- By adding the Brick wastes in CL soil, CBR improvement is possible upto 5 times the initial value with respect to the addition upto 60%
- 10 to 20 tonnes of Demolition waste has been produced every year in India

Shredded Rubber tyre Scrap

- When soil is mixed with 10% rubber its CBR value increases by 9% compared to virgin soil, which tends to be the maximum CBR value of all to mixtures.
- It was seen that when soil was mixed with 15% rubber the CBR value was found to be drastically decrease so the optimum dosage of shredded rubber in the soil must be around 10% of the total weight.

5. Conclusion:

If correct mixing and compaction is done, there is a considerable improvement in CBR Value of sub-grade due to the addition of the following materials:

Foundry sand, granite dust, quarry dust, demolition wastes, and shredded rubber tyre trash. These materials must be proportioned as shown in the discussion section. The load carrying capacity of the model flexible pavement system is significantly increased by introducing reinforcement material in gravel sub bases laid on expansive soil sub grade. The total and elastic deformation values of the flexible pavement system are decreased by the provision of the reinforcement viz: Geo grid, BCCM, BCBM, WP and WTR stretches in gravel sub bases laid on expansive soil sub grade. The maximum load carrying capacity followed by less value of rebound deflection is obtained for Geo grid reinforced sub base stretch followed by other stretches laid in gravel sub base of the flexible pavement system. These wastes can be economically added to meet the degree of improvement for Expansive soils unless they are deposited somewhere else. However, these materials are beneficial in improving less potential expansive soils, and we cannot accomplish the same high level of improvement as we can with cementing materials such as cement, lime, bitumen, and fly ash. It is my opinion that producing PPC and Ash Bricks with Fly Ash is preferable". We shall reassure the routine of inert wastes as revealed in this review paper for sprawling soil progress.

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