# IMPROVEMENT OF SOIL BY USING STONE AGGREGATE AND GEOSYNTHETIC

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***Abstract*: Engineers often face problem in constructing road bed on weak subgrade soil. These soils can be strengthened by adding various types of materials, by compacting them into required CBR value as per highway requirements. Some natural resources such as gravel are not renewable, therefore, it is necessary to reduce the use of such resources and replace them with other economic, and environmentally friendly materials. The present study focused on using crushed concrete in improvement the chemical and geotechnical properties of soft soil having undrained shear strength of 6.78 kPa. The soft soil samples were mixed with 5, 10, and 15% of crushed concrete. Such aggregates are lighter than natural aggregates and provide a good deformation modulus when mixed with soil. In Iraq, there are hundred thousand tons of concrete blocks used as fences and now considered wastes after removing these security fences, so it's important to interest from recycling of such materials to be used in the improvement wide region of soft soils in Iraq. The results of tests showed increasing the undrained shear strength of soft soil by 175-193.5% and reduced the compressibility of soft by 25-31% measured in terms of compression index.**

**The aim of this study was to gather data to quantify the benefit of the use of geotextiles on secondary routes. A small-scale study in the laboratory was performed to try to develop a simple method for rapidly assessing the possible benefit under a wide range of conditions. A field study is also underway to provide calibration of laboratory results and experience under full-scale, real-world conditions. The field study is configured so as not to accelerate pavement deterioration intentionally or otherwise attempt to modify the structure of the subject pavements.**

**Index Terms: soil, Pavement, Aggregate, Maximum Load Test, Geotextile.**

## I. INTRODUCTION

Geosynthetics have increasingly been used since the 1960s in pavement structures to provide reinforcement; to serve as a permeable separator to prevent mixing of subgrade with subbase or base course materials; and to provide drainage. A reliable method of quantifying these benefits is needed to justify the more widespread use of these materials. The purpose of this study was to quantify the benefit of using a geotextile as a separator in low-volume roadways such as secondary and subdivision streets. A field trial was conducted on a section to achieve this objective. A geotextile was placed between the aggregate base and subgrade in one lane of the section to prevent failure attributable to intermixing, and the adjacent lane was left unmodified as a control. In addition to the field trial, a small-scale accelerated loading laboratory test was conducted to quantify the benefit of using geotextile as a separator for a range of pavement design variables, including variations in soil strength, traffic volume, and aggregate properties.

A statistical analysis of data gathered by a falling weight deflectometer during construction and after 8 months of traffic showed the lane with geotextile to have a slightly higher structural capacity. As severe intermixing and base failure in the control section were not expected during the 8-month period because of the low volume of traffic and a dry season, the benefit may have been attributable to a reinforcing effect.

Although the size of the apparatus and the boundary condition may have prevented the most accurate quantification of the benefit, the laboratory testing further demonstrated the benefit. Most laboratory samples with geotextile had less deformation than the control sample. Intermixing of soil and aggregate was not observed when very densely graded base aggregate was used. When a more open-graded aggregate was used, the geotextile reduced the amount of fines migration into the aggregate layer; however, the fouled aggregate did not appear to have lost significant structural stiffness. Therefore, the separator benefit of geotextile in the laboratory testing was also apparently attributable to a reinforcing effect. The use of geotextile materials appears to have great potential to extend the service life of pavements on the secondary road system, offering significant cost savings to VDOT. It is recommended that this section of road be periodically evaluated to quantify this potential increased service and that more test sections on subdivision streets with a weaker subgrade condition or full-scale accelerated testing be conducted for a reliable quantification of the benefit.

## II. MATERIALS AND METHODS

### a) Materials

**The material used in the present research work are:-**

- **Soil:-** The soil samples were obtained from a depth of 1.5 to 2 m below the ground level. Shelby tubes were used to obtain undisturbed soil samples. After the excavation, the Shelby tubes with a sharp bottom edge were pushed vertically into the soil under hydraulic pressure and extracted after removing the surrounding soil by hand drilling. Also, the soil sample of Shelby tubes is used to calculate the field moisture content (16.5%) and density of the soil (1.715 g/cm3). Disturbed soil samples are obtained by hand drilling from the test pit.

- **Geo Textile: -** Geotextile is known as a fibrous material that is used with soil environment and contains non-woven and woven materials with polymers, natural products like jute, fabricated with the use of textile process. Polypropylene: When you polymerize the monomers of propylene with specific catalysts, it gives birth to thermoplastic polypropylene in a crystalline environment. Geotextile was directly purchase from the market according to the required specification.

- **Aggregate:-** The aggregates used for the study is collected from the Panipat. The size of the aggregates used in this study varies from 10-12mm.

**b) Methods**

- **Sampling:-** Samples of soil, geosynthetic material and crushed aggregate was collected from the different sampling station.
- **Preparation of sample: -** After the collection of samples it was prepared for analysis. It was firstly cleaned and left over night for air dry. Then is was sieve from 4.75 mm sieve as to maintain uniformity in the particle of sample.
- **Characterization of Crushed aggregate:-** The physical properties of aggregate was examine.
- **Geotechnical analysis of Soil:-** Geotechnical property of the fly ash was analyzed in the Geotechnical Laboratory by performing geotechnical test.
- **Characterization of geotextile:-** the characterization of collected geotextile was done as to analyze the compatibility of it geotextile for reinforcement.
- **Preparation of Stone Column:-** After the Analysis of characteristics the Stone Column was prepared. Three types of Stone Column sample were prepared. One sample in which single layer of geotextile was used. Second sample in which double layer of geotextile was used and in third sample four layers of geotextile was used
Stone Column made was left overnight in order to get air dry in the reinforcement and then it was subjected to analysis.
- **Analysis of Stone Column: -** After the making of Stone Column all these Stone Column were subjected to analysis of stability for the use of Stone Column which include Maximum Load Test.

## III. RESULTS

**RESULT FOR ANALYSIS OF SOIL**

| Properties of the sample | Value | Remarks |
|---|---|---|
| Soil | Sand | - |
| Classification of Soil | SP | - |
| Angle of Friction (ϕ) | 20° | IS 2720 – 13 (BIS 1986 (a)) |
| Cohesion (c) | 1.96 kN/m² | |
| Specific Gravity | 2.65 | Pycnometer Method<br>Clause 8.3 BS 1377 : Part 2 (1990) |
| Water Content | 3.44% | - |
| Optimum Moisture Content | 8.40% | BS 1377 : Part 4 (1990) |
| Dry Density | 0.0016 kg/cm³ | |
| Bulk Unit Weight ($\gamma_{unsat.}$) | 19.66 kN/m³ | |
| Saturated Unit Weight ($\gamma_{sat.}$) | 21.75 kN/m³ | |
| Poisson's ratio | 0.30 | IS 9221-1979 |
| Modulus of elasticity | 20,000 kN/m² | |

**RESULT FOR ANALYSIS OF CRUSHED AGGREGATE**

| Parameter | Aggregates | Remarks |
|---|---|---|
| Classification | GW | - |
| Friction angle ($\phi$) | 42° | IS 2720 – 13 (BIS 1986 (a)) |
| Cohesion (c) | 0.10 kN/m$^2$ | |
| Bulk Unit Weight ($\gamma_{unsat.}$) | 22.78kN/m$^3$ | BS 1377 : Part 4 (1990) |
| Saturated Unit Weight ($\gamma_{sat.}$) | 23.25 kN/m$^3$ | |
| Poisson's ratio | 0.30 | IS 9221-1979 |
| Modulus of Elasticity | 55,000kN/m$^2$ | |

**CHARACTERISATION OF GEOTEXTILE**

| S. No. | Property | Value |
|---|---|---|
| 1 | Tensile Strength | 5 KN/m |
| 2 | Grab Tensile Strength | 5 KN |
| 3 | Roll Width | 5 m |
| 4 | A.O.S | 65 m |
| 5 | Trapezoidal Tear Strength | 165 N |
| 6 | CBR Strength | 750 |

**RESULT FOR STONE COLUMN ANALYSIS**

| Type of Reinforcement | Experimental Results | | | Average Value (kN) | Final Settlement (mm) |
|---|---|---|---|---|---|
| | End Load (kN) (First Trial) | End Load (kN) (Second Trial) | End Load (kN) (Third Trial) | | |
| Single un-reinforced column | 7 | 7.20 | 7.10 | 7.10 | 30.00 |
| Single vertically encased column | 14 | 14.70 | 14.20 | 14.30 | 30 .00 |
| Single horizontally reinforced column | 14.5 | 15.5 | 15 | 15.00 | 30.00 |
| Group of 3 unreinforced columns | 17.00 | 16.90 | 17.70 | 17.20 | 30.00 |
| Group of 3 vertically encased columns | 21.80 | 22.10 | 22.70 | 22.20 | 30.00 |
| Group of 3 horizontally reinforced columns | 22.40 | 22.50 | 22.60 | 22.50 | 30.00 |
| Group of 4 unreinforced columns | 20.50 | 20 | 20.70 | 20.40 | 30.00 |
| Group of 4 vertically encased columns | 24.70 | 24.40 | 24.10 | 24.40 | 30.00 |
| Group of 4 horizontally reinforced columns | 24.90 | 24.80 | 25 | 24.90 | 30.00 |

## IV. CONCLUSION

Based on the testing done and results obtained the followings conclusions were made

- Vertically enclosed stone columns increased bearing capacity by providing a 47.33% boost, while horizontal reinforcement gave a 49.65% rise.
- Vertically-incased 3-stone columns increased bearing capacity by 76.44% while horizontal reinforcement increased bearing capacity by 77.47%
- The findings from the model testing showed that although unreinforced 3-stone columns had a bearing capacity, the test model's bearing capacity was more than that of 3 unreinforced stone columns.
- Vertically encased 4 stone columns increased bearing capacity by 81.92 percent, compared to the horizontal reinforcement, which provided an additional 83.60 percent capacity increase in the bearing. The results from the modelling experiment comparing Unreinforced 3 stone columns to Vertical Reinforcement 4 stone columns can be observed in the figure.
- Adding lateral confinement to stone columns is done using geosynthetic encasement, which mobilizes hoop pressures. In contrast, friction horizontal reinforcement keeps columns from bulging. Horizontal soil reinforcement proved to be better at carrying loads than enclosed columns.
- Geotextile reinforcement requires the use of hoop stresses and increased load bearing strength, all of which are attained at the same time, as opposed to unreinforced stone columns. Additional results: Additionally, horizontal reinforcement improves aggregate shearing tolerance, which causes a greater load-carrying capacity for the aggregate-geotextile-aggregate composite than a vertically enclosed floating column.

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