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CHEMICAL SOIL STABILIZATION OF THE BANKS OF RIVER GHAGHARA

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Abstract

In this paper, fly-ash is used for the stabilization of the soil along the banks of river Ghaghara to prevent soil erosion that is caused by the flood. The sample from the site was obtained and different index properties test were performed. According to the optimum moisture calculated, the percentage of moisture content for the soil fly-ash mixture is taken as 25%. Three samples with fly-ash percentage viz. 10%, 15%, 20% are prepared and further direct shear test is performed. It can be seen that the 15% fly ash-Soil sample is found to be appropriate for preventing the lateral erosion as the shear strength of the 15% fly-ash mixture is greater than the critical shear strength of the soil. Thus the use of fly ash can be effective in improving the index properties of soil present at the site.

Keywords:

Soil Erosion, Soil Stabilization, Geomorphology, Sedimentology, Regolith

1. Introduction

India has been gone through several natural disasters like Flood, Drought, Cyclone, Earthquakes, Landslides and Avalanches. The problem of soil erosion is prevalent all over the regions of India. The habitat along the rivers suffers from flooding every year and this has become a major problem of India. During the four months of monsoon i.e. June to September, 75% of the total annual rainfall occurs due to this all the rivers flow with heavy discharge. Besides flood hazard, the problems of deposition of sediment, congestion in drainage and synchronization of river floods with sea tides in the coastal plains, also exists in the region. Uttar Pradesh, one of the most flood-affected states in India with 7.336-million- hectare area liable to floods. Uttar Pradesh has experienced massive flooding in 1998, 2000, 2001, 2008, 2011, 2013, and 2014. The occurrence of the flooding is common in eastern portions of Uttar Pradesh (U.P.). The flood results spilling of the many rivers present in the eastern portions i.e. Ghaghara and Gandak. Rivers of Ganga plain i.e. Gandak, and Sharda has been studied for sedimentology, geomorphology and flood physiognomies. The middle Ganga basin and Ghaghara River have problem of channel migration. Generally, the Ghaghara River faced lateral erosion. However, side erosion is more predominant in the middle reaches, where thin channel is restricted within widespread valley. This wide valley composes silty and sandy soil. These soil having low or poor degree of compaction. For the period of low-discharge lateral erosion is a severe threat between Gothani and Barhaj. The Ghaghara River flows above the danger mark at Elgin Bridge during the Summer-monsoon season every year. The paper is mainly focused on preventing soil erosion that is caused by the flood, occurring in the river Ghaghara. Due to the soil erosion the width of the river is increasing which is affecting the livelihood of the nearby area. The paper uses chemical soil stabilization technique to prevent the lateral and longitudinal erosion at the bank of river Ghaghara.

2. Erosion

Erosion is the process by which soil is eroded away from the Earth's surface by exogenic processes such as water flow, wind and gets transported and deposited in other locations. Due to erosion the rivers changes in four dimensions viz. Lateral, Longitudinal, Vertical and Temporal. There are three kinds of erosion namely Particle shearing, Mass wasting and Rill & gully erosion.

2.1 Particle shearing is the migration of soil particle due shearing force exerted by flowing water. The soil particle lifts and motion starts when resistance to the fluid shear force reaches a critical stage and exceeds.

2.2 Mass wasting is the process by which soil, regolith, sand, and rock move down the slope as a mass, largely under the force of gravity, but frequently affected by water content as in submarine environments and mudslides. This geomorphic process is also known as slope movement or mass movement.

2.3 Rills are elementary channels which form during the surface runoff event due to the concentration of flow. These are temporary features and facilitate channeling of overland flow. The flow in rills cuts the surface, detaches and transports the sediments in surface runoff.

2.4 Gullies are formed due to confluence of many rills and formation of major rill. When a major rill becomes deeper and steeper a gully is formed. The sediment removed due to formation, enlargement and deepening of gullies is known as gulley erosion.

3. Soil Stabilization

Soil Stabilization is a method of improving the engineering properties of soil and therefore making it more stable. Stabilization includes pre-consolidation, compaction and numerous other similar methods. However, stabilization is usually related to the processes which modify the soil composition itself for enhancement of its properties. For the purpose of stabilization, a compound or a cementing material is added to a natural soil. Soil stabilization increases shear strength, reduces permeability and compressibility (Gregory Paul Makusa). As the soil along the banks of river Ghaghara is cohesive thus the paper employs lime stabilization method to prevent erosion. Lime stabilization is the application of pozzolanic material to the soil in certain concentration to increase its resistance to erosion. The reaction of a soil with quick lime, or cement is important for stabilization. There is exchange of cations in the adsorbed water layer and a decrease in plasticity of soil. The soil properties and characteristics that affect the soils ability to react with lime to produce cementitious materials are organic content, pH, clay mineralogy, and natural drainage. Treated soils results in increased particle size with reduction in plasticity, cementation, increase in internal friction among the agglomerates, increased shear strength, and increased workability caused to the textural change from plastic clay to friable, sand like material. This treated soil will resist the forces caused by the flowing water. Paper employees the use of Fly-ash as pozzolanic material; it contains Calcium oxide which on reaction with moisture present in the soil forms Calcium Hydroxide. Further this Calcium Hydroxide reacts with Silica present in fly-ash to produce calcium silicate hydrate (C-S-H) binder. (Arora, K. R., 2000). The following equations illustrate the pozzolanic reaction:

CaOH + S silica from ash constituents C-S-H

Fly ash is among one of the residues obtained during the combustion of coal in coal-fired power plants. Fine particles rise with flue gasses and are collected with electrostatic precipitators or filter bags.

Fly-ash has following advantages:

Fly ash is a by-product material which is traditionally a waste that must be disposed of or recycled. Thus it can be used for stabilization purpose.

Reduces the energy investment in processing virgin materials.

A cheap stabilization material than other alternatives available.

Conserves virgin materials.

The use of Fly-ash reduces pollution.

4. Methodology

The sediments of sand and silt are non-cohesive in nature. They are in unconsolidated form, hence they can undergo transportation, weathering, and sliding. Fractures developed in clayey facies of the river bank during summers. The deposits are parallel to the direction of the river lineament or fault. There is a high frequency of the formation of these fractures during low-discharge period. These fractures are 10 to20 m in length and 5to10 cm wide. To prevent lateral soil erosion, the cohesive property of the soil, angle of repose and shear strength has to be improved so that the soil can attain stability at steeper angles. Fly-ash as the stabilizing chemical has been used to modify the required soil properties. Soil-fly ash mixtures with various percentage of fly ash were prepared followed by their analysis to obtain required results.

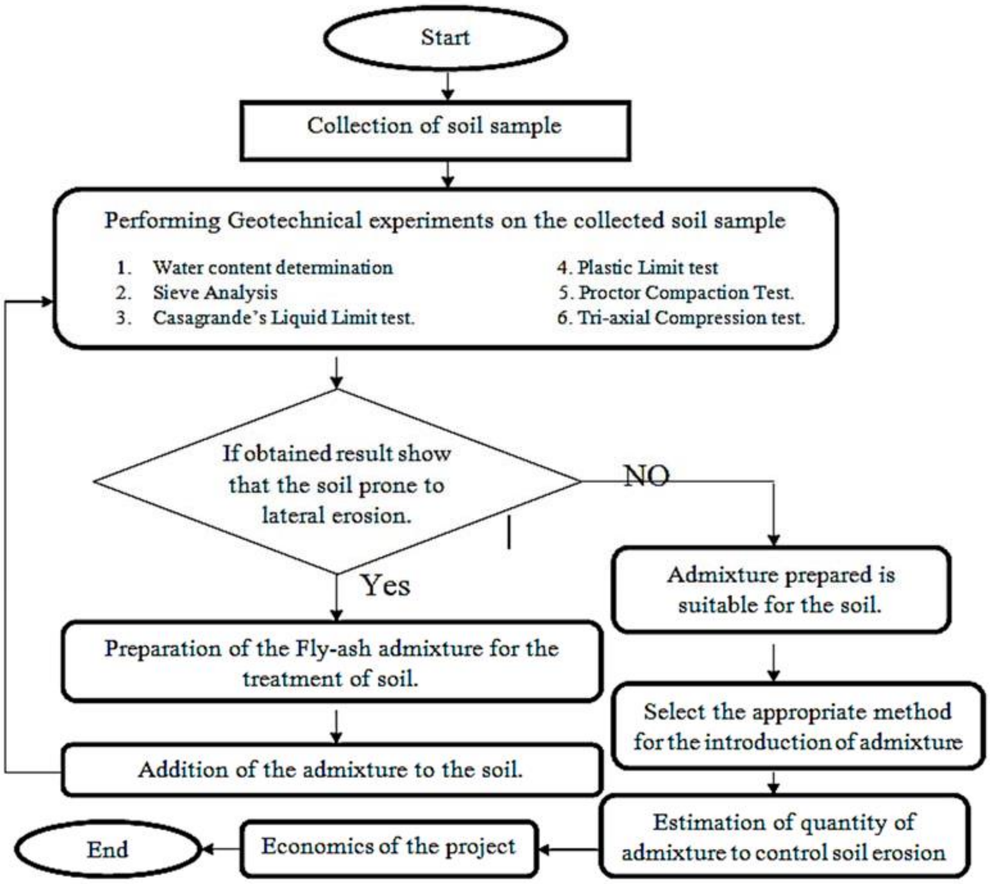

Figure 1: *Flow Chart for Methodology*

Figure 1 shows the flow chart for the proposed methodology that can be used to prevent the soil erosion at the river banks.

5. Study Area

Location: Ghaghara river bank near Sansay Setu, Bahraich.
Coordinates: 27° 5’ 40.6’’ N & 81° 28’ 40.7’’ E
Elevation: 88m

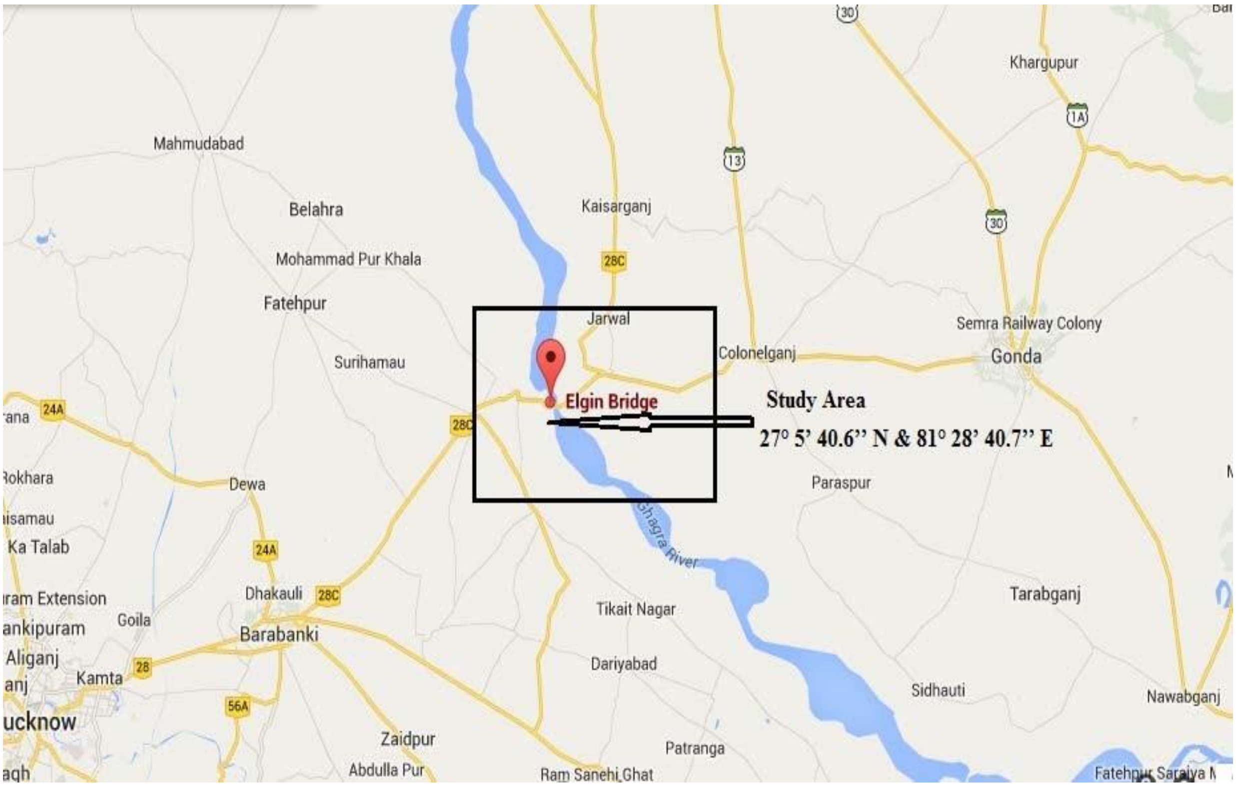

Figure 2: *Location Map of Study Area*
(Source: Google Map)

6. Data Collection and Analysis

The soil was collected using auger boring method at 0.25 m, 0.5m, and 1 m depth. Fly-ash was obtained from NTPC, Unchahar, U.P., India.

7. Analysis of the Soil Sample

Various geotechnical experiments were performed on the soil sample obtained from the site the results of which are as follows (Dayakar, P. (2012).:

Water content (w) = 30.4%

Plastic limit Test: The test failed due to crumbing of the thread before making it of 3 mm diameter.

Critical Shear Stress: τ_c = 1.552 kg/cm^2

Grain size distribution:

Coefficient of curvature C_C =0.352,

Coefficient of uniformity C_u = 9.2

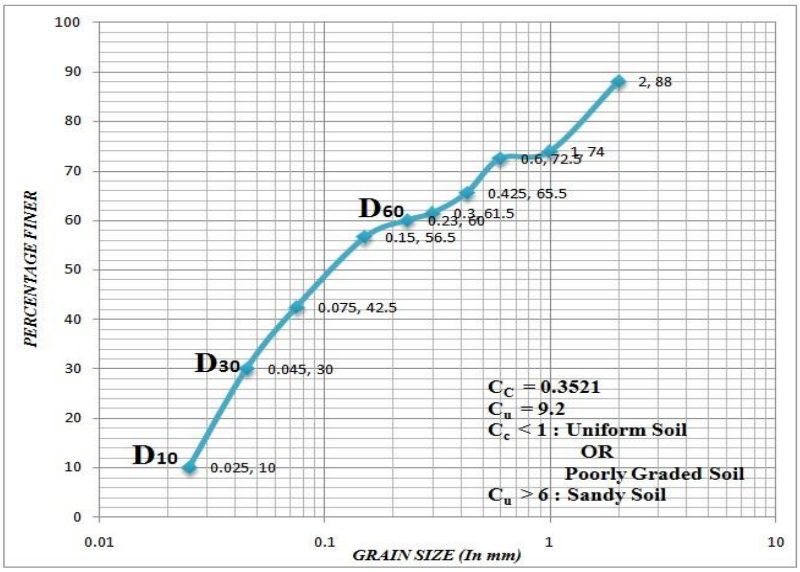

Figure 3: *Grain Size Distribution Curve*

Liquid Limit Test: LL= 27%

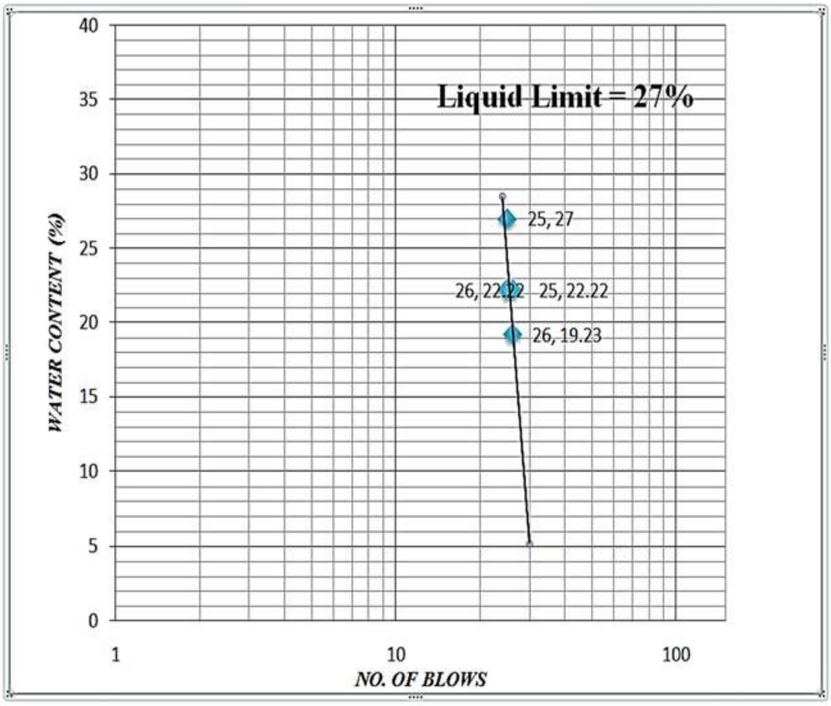

Figure 4: *Liquid Limit Curve*

Proctor's Compaction Test:

Optimum Moisture Content = 27%.

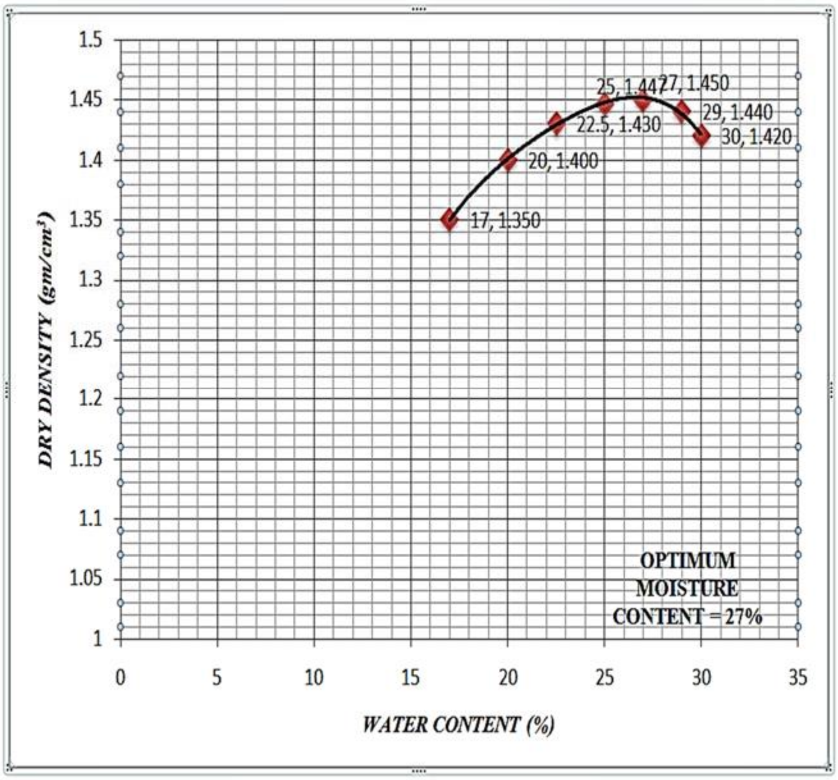

Figure 5: *O.M.C. Curve*

Direct Shear Test: Shear strength at failure (τ_f) = 1.08 kg/cm^2,

Cohesion C' = 0.96 kg/cm^2.

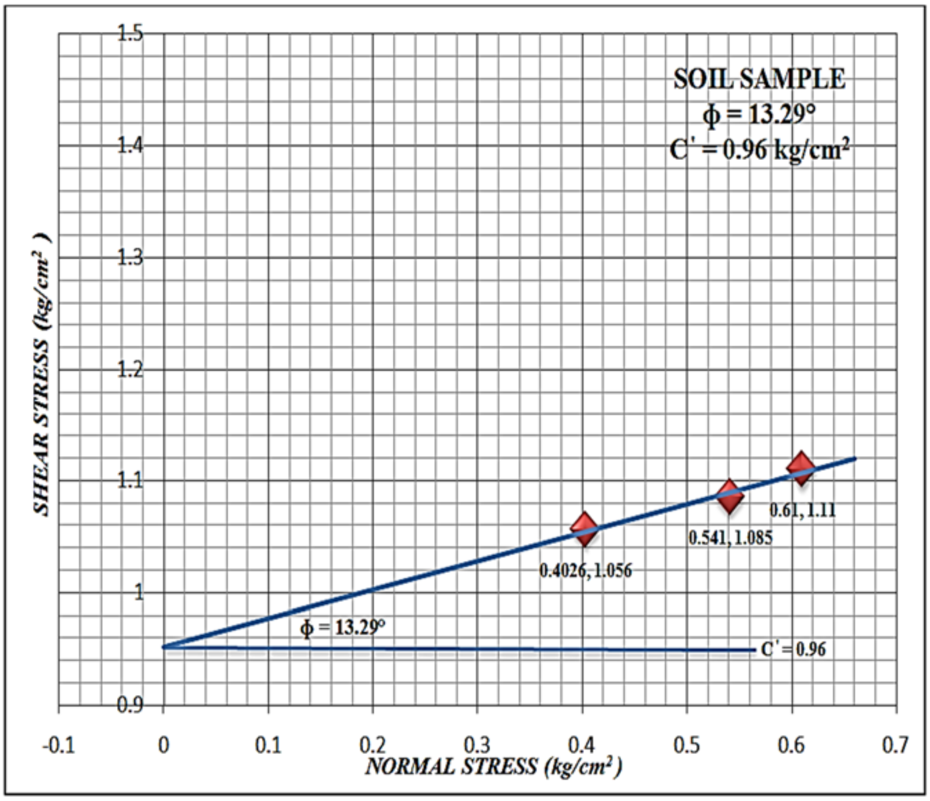

Figure 6: *Coulomb's Envelope*

Soil is uniform sandy with low cohesion and shear strength value due to which lateral erosion prevails along the banks of river Ghaghara.

8. Preparation and Analysis of Soil Fly-Ash Mixture

According to the optimum moisture content calculated the percentage of the moisture content for the soil fly-ash mixture is taken as 25%. Three samples with fly-ash percentage viz. 10%,

15%, 20% are prepared and further direct shear test is performed.

Size of Soil sample = 6 x 6 cm^2

Weight of yoke, w_1=0.775 Kg.

Weight of Loading pad, w_2=0.620 Kg.

Lever Ratio = 1:5

Proving ring Constant (K): 1Division= 2 Kg.

Rate of strain for Horizontal Shear = 1.25 mm/min.

8.1. Soil + 10% Fly-ash Mixture

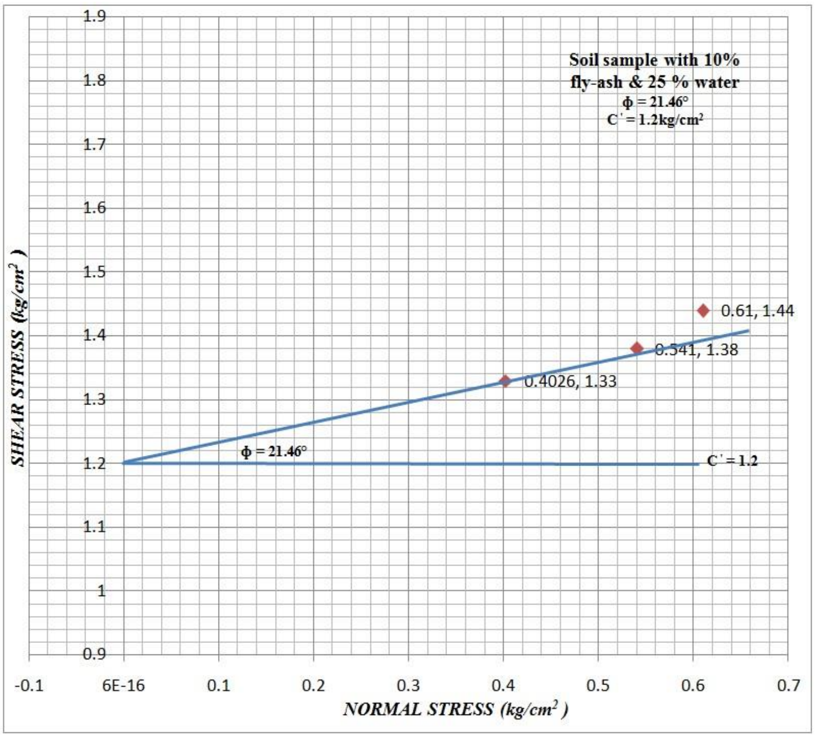

Figure 7: *Coulomb's Envelope for Soil + 10% Fly-ash Mixture*

Shear strength at failure (τ_f) = 1.38 kg/cm^2

Cohesion C’ = 1.2 kg/cm^2.

ϕ = 21.46°

8.2. Soil + 15% Fly-Ash Mixture

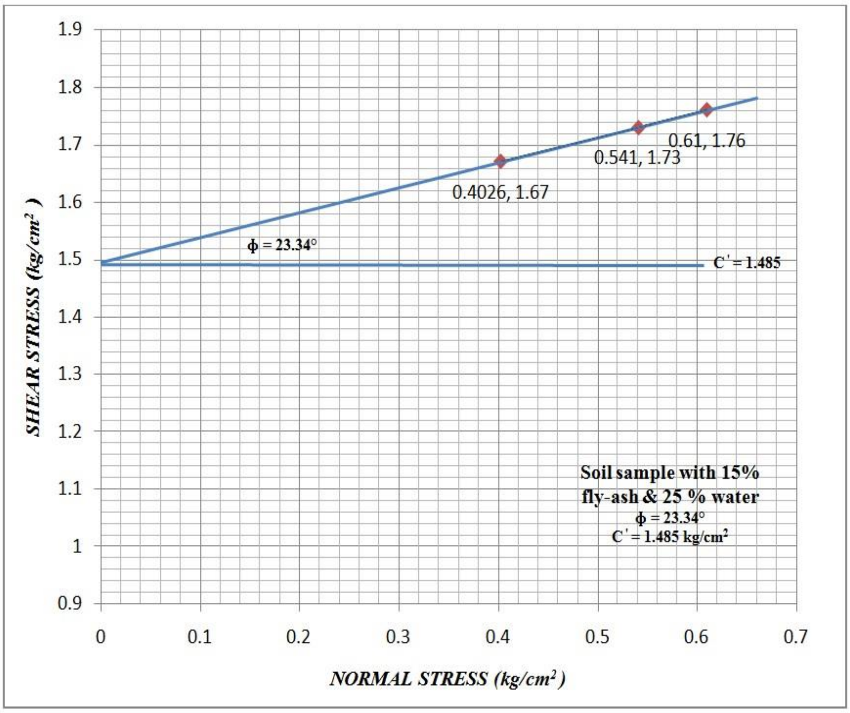

Figure 8: *Coulomb's Envelope for Soil + 15% Fly-ash Mixture*

Shear strength at failure (τ_f) = 1.72 kg/cm^2

Cohesion C' = 1.485 kg/cm^2.

ϕ = 23.34°

8.3. Soil + 20% Fly-ash Mixture

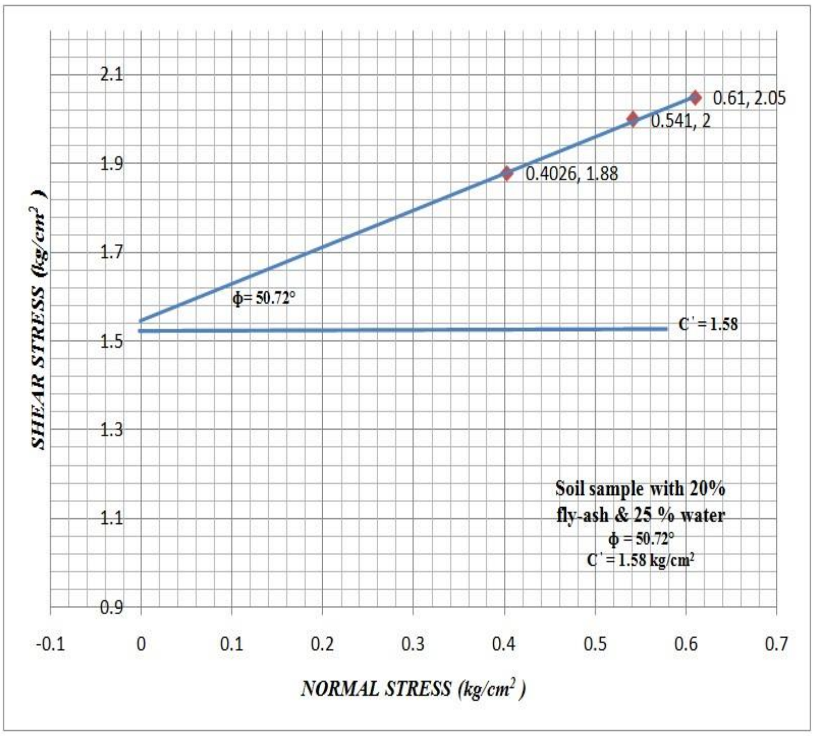

Figure 9: *Coulomb's Envelope for Soil + 20% Fly-ash Mixture*

Shear strength at failure (τ_f) = 1.97 kg/cm^2

Cohesion C' = 1.58 kg/cm^2.

ϕ = 50.72°

9. Results and Conclusion

On the basis of the experimental study following conclusion can be drawn-

(i) Fly ash is comparatively economical material for large-scale soil stabilization projects.

(ii) The applicability of the fly ash was found adequate for soils, which are continuously in the contact of the water.

(iii)The optimum amount of the fly ash soil sample is found 15% for preventing the lateral erosion. Since the shear strength of the 15% fly-ash mixture is greater than the critical shear strength of the soil.

These results are based on the collected samples form the Ghaghara river bank form the specific location on specified time. Actual results may vary from the obtained results depending upon the type of the soil, location and time.

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V. K. Mathuv. Mathur, AGM / NTPC "*NTPC efforts to enhance ash utilization"*