Effect of Gravel And Laterite Content on The Shear Strength of Sand Mixtures

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Abstract- *In certain situations, sand is required to have extra shear strength to provide more safety, stability and support for structures. Shear strength in sand arises from friction and resistance between particles. The most common means of increasing the shear strength of sand is the cementation method. Another practice is using an additive such as gravel, laterite soil, etc. Many natural slopes and rock fill structures are made of a mixture of dispersed rock fragments (gravel) and sand-size particles. To analyze the stability of such structures, the shear strength of the sand-gravel mixtures is needed. For this purpose, direct shear tests were carried out on mixtures of river sand – gravel mixture and sand – gravel – laterite mixture. The shear strength of the sand, sand-gravel mixtures and sand – gravel – laterite mixture was measured under three normal stresses. These normal stresses were equal to 50kPa, 100kPa and 150kPa. During the tests, the concentration by weight of the gravel in the mixtures tested varied between 5 and 15%. The results of the direct shear strength tests indicated that the angle of internal friction improved with an increase in the concentration of the gravel and laterite in the mixtures. The angle of internal friction was equal to* 24^0 *for the sand alone. The friction angle increased for the sand sample with increase in concentrations of gravel and laterite in sand -gravel mixture and sand – gravel – laterite mixture respectively. The shear strength of the sand mixtures are increases with increasing gravel and laterite up to a certain percentage and then decreases. The maximum shear strength is obtained at 10% of gravel and laterite content in both sand gravel mixture and sand gravel laterite mixture.*

Keywords- Shear strength, angle of internal friction.

I. INTRODUCTION

Sand is a granular material that composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; that is, a soil containing more than 85 percent sand-sized particles by mass.

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 can be done with cement, bitumen, lime, chemical stabilization, geotextile, grouting etc. It is a method of improving soil properties by blending and mixing other materials.

Soils containing dispersed or “floating” large particles are common around the world and form part of engineered fills, glacial tills, mudflows, debris flows, alluvial, residual, colluvial and desert soil deposits. It is common practice to improve the mechanical properties of solid materials by reinforcing them through the addition of large rigid particles. Here the sand is reinforced with gravel particles. In such cases, sand gravel mixtures may have chances to increase the permeability with increasing gravel contents. To reduce such problems, some fine particles like laterite soil is added to the sand – gravel mixture and compare the results. Here used the samples as sand – gravel mixture and sand – gravel – laterite mixture and they allow to shear test.

II. OBJECTIVES

- To determine the basic properties of samples.
- To determine the particle size gradation.
- To determine the shear strength of sand gravel mixture with 5, 10 and 15% of gravel content.
- To determine the shear strength of sand gravel laterite mixture with 5, 10 and 15% of gravel and laterite content.
- To compare the results and find out the percentage of gravel and laterite which gives the maximum shear strength.

III. MATERIALS AND METHODOLOGY

The materials used are the river sand, river gravel and laterite soil. The river sand and river gravel were collected from the bank of Kadalundi river near the Nooradi bridge, Malappuram and the laterite soil were collected from the site of laterite brick construction at konompara, Malappuram. The average size of sand particles used for the study is 0.59mm, gravel particles is 2mm and laterite of 0.425mm.

The tests were carried out on the collected sandy soil without adding the gravel and laterite. such that the effect of the additive could easily be measured. Basic properties of the soil were determined.

The shear strength was determined by using direct shear test. First determine the shear strength of sand and then add gravel particles by various percentages. Then find out the shear strength of sand gravel mixture. After that add laterite and gravel to the sand by various percentages for finding the shear strength of sand gravel laterite mixture. The direct shear apparatus is shown below in figure 3.1.

Fig. 3.1 Direct Shear Apparatus

IV. RESULTS AND DISCUSSION

The tests for index properties and engineering properties of river sand, river gravel and laterite soil were determined by conducting series of laboratory experiments. Properties of sand were tabulated in table 4.1 and gravel in table 4.2.

Table 4.1 Properties of River Sand

Soil properties	Values
Specific gravity	2.656
Uniformity coefficient, Cu	2.33
Coefficient of curvature, Cc	0.762
Permeability value	$9.17x10^{-4}$
Dry density (loose condition), g/cc	1.485
Angle of internal friction (ɸ)	24^0

Table 4.2 Properties of River Gravel

Soil properties	Values
Specific gravity	2.5
Uniformity coefficient, Cu	2.30
Coefficient of curvature, Cc	1.0708
Impact value (%)	33.52
Crushing value (%)	31.96

Table 4.4 Properties of Laterite soil

Property	Value
Specific gravity	2.66
Liquid Limit	37%
Plastic limit	25%
Shrinkage limit	8.3%
Plasticity index	12%
Soil type	MI
Dry unit Weight(g/cc)	1.95
Optimum moisture content	18.5%
Unconfined compressive strength	47.9kN/m^2

The shear strength of the sand-gravel mixtures mixture was measured under three normal stresses. These normal stresses were equal to 50kPa, 100kPa and 150kPa. During the tests, the concentration by weight of the gravel in the mixtures is varied between 5 and 15%.

The test result is classified for each percentage of gravel in sand – gravel mixture as 5%, 10% and 15%. The figure 4.1 shows the shear strain vs shear stress diagram of 5% gravel added to the sand under 50, 100 and 150 kPa loads.

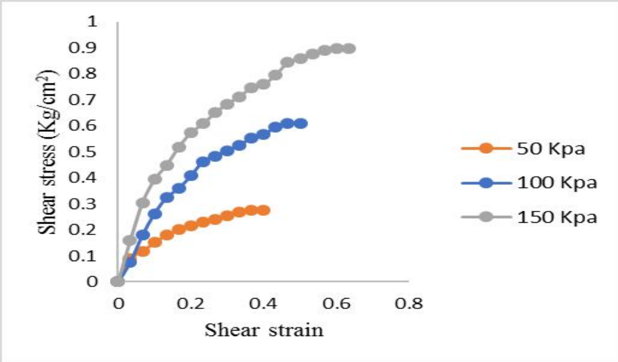

Fig. 4.1 Stress Strain Curve For 5% Gravel

Figure 4.2 shows the relationship between shear stress and shear strain. From the graph, the maximum shear stress was found as 0.899Kg/cm^2 obtained when 150 kPa load was applied.

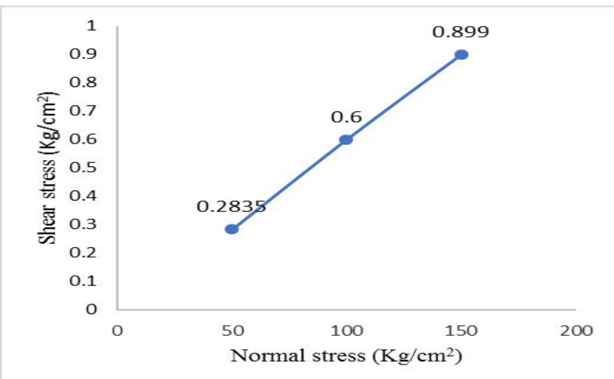

Fig. 4.2 Shear Stress Vs Normal Stress Curve For 5% Gravel

The figure 4.3 shows the stress strain curve for sand – gravel mixture of 10% gravel content by weight of the sand.

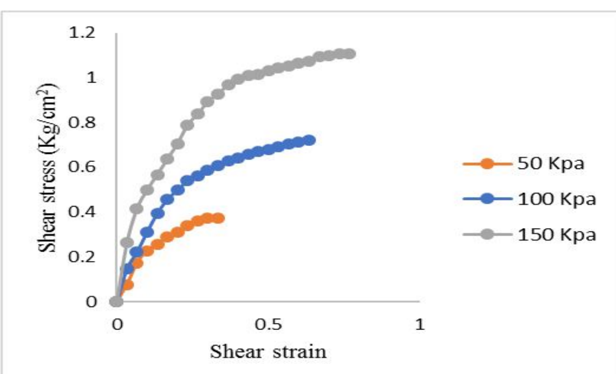

Fig. 4.3 Stress Strain Curve For 10% Gravel

From the figure 4.4, the maximum shear stress was found as 1.10Kg/cm^2 obtained when 150 kPa load was applied. The value of shear stress is higher than the 5% gravel content at the same loading.

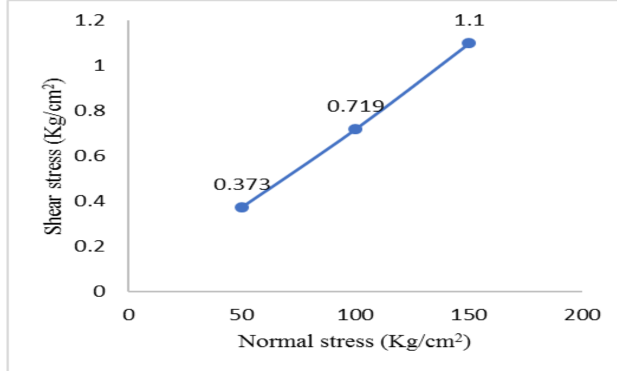

Fig. 4.4 Shear Stress Vs Normal Stress Curve For 10% Gravel

The following figure 4.5 shows the shear strain vs shear stress diagram of 15% gravel added to the sand under 50, 100 and 150 kPa loads.

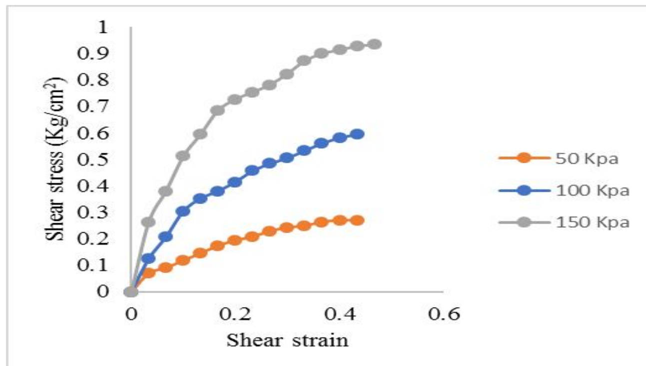

Fig. 4.5 Stress Strain Curve For 15% Gravel

From the figure 4.6, the maximum shear stress was found as 0.933Kg/cm^{2}was obtained when 150 kPa load applied. The obtained value of shear stress is less than that of 10% gravel content and greater than 5% gravel content of sand – gravel mixture.

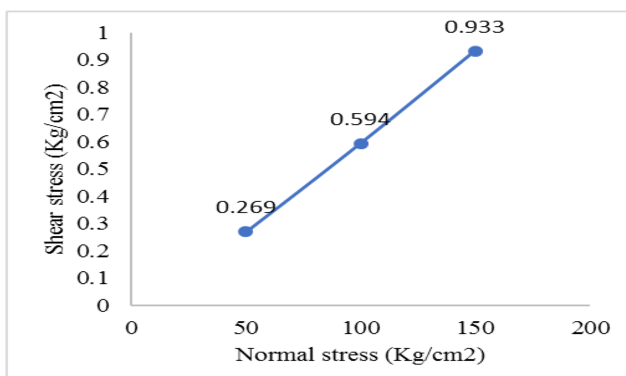

Fig. 4.6 Shear Stress Vs Normal Stress Curve For 15% Gravel

By analyzing the experiments, it can be found that the maximum shear stress was obtained when 10% gravel was added to the sand. It means that the maximum shear strength is obtained for 10% of gravel content in sand gravel mixture. In this condition the sand and gravel contents are in good binding condition than the other percentages.

The following graph (**Fig. 4.7**) shows the relationship between maximum shear stress versus percentage of gravel content in sand – gravel mixture.

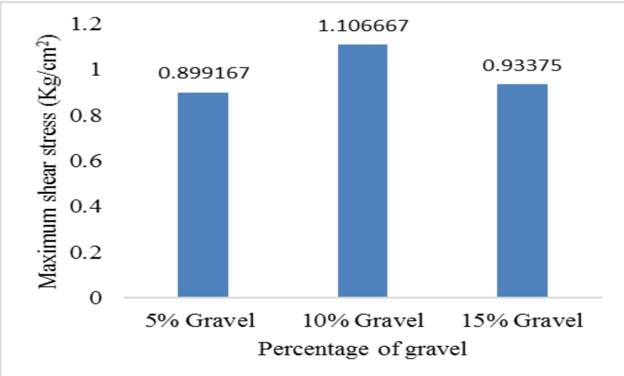

Fig. 4.7 Comparison of Maximum Shear Stress of Sand – Gravel Mixture

Sand – gravel – laterite mixture is a mixture of sand, gravel and laterite with major content of sand. A series of direct shear tests were conducted to examine the shear strength of the sand composite, starting with pure sand specimen, progressing to the sand containing various percentages of river gravel and laterite soil with dry condition.

The percentages of gravel and laterite to the sand specimens were 5%, 10%, and 15%. Three normal stresses of 50, 100 and 150kPa were applied in each series of tests. During the tests, the concentration by weight of the gravel and laterite in the mixtures is varied between 5 and 15%.

The following figure shows the shear strain vs shear stress diagram of 5% gravel and laterite added to the sand under 50, 100 and 150 kPa loads.

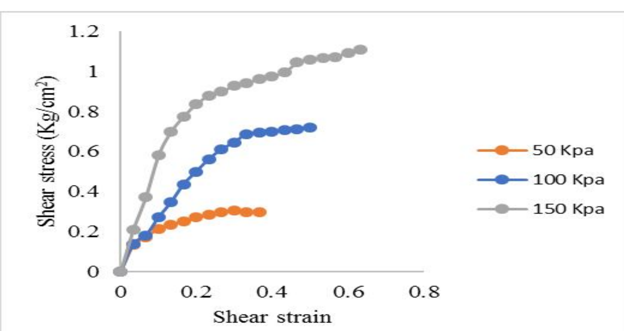

Fig. 4.8 Stress Strain Curve For 5% Gravel And Laterite

The figure 4.8 shows the relationship between shear stress and shear strain. From the figure 4.9, the maximum shear stress was found as 1.106Kg/cm^2 obtained when 150 kPa load was applied.

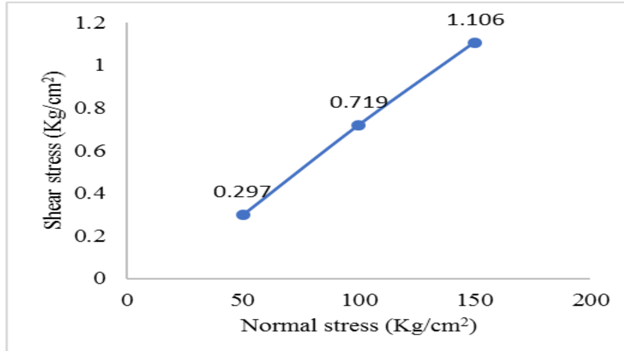

Fig. 4.9 Shear Stress Vs Normal Stress Curve For 5% Gravel + Laterite

The figure 4.10 shows the stress strain curve for sand – gravel – laterite mixture of 10% gravel and laterite content by weight of the sand. Here we also applying three loading conditions such as 50, 100 and 150kPa.

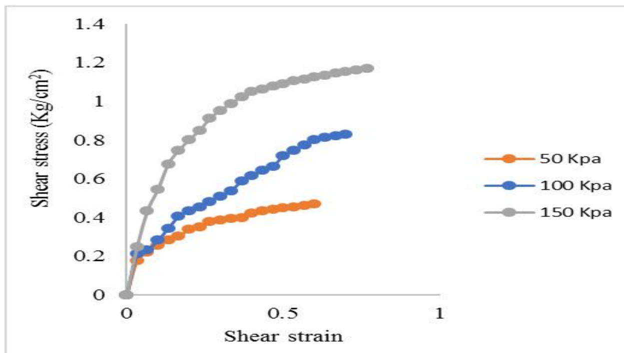

Fig. 4.10 Stress Strain Curve For 10% Gravel And Laterite

From the figure 4.11, the maximum shear stress was found as 1.16Kg/cm^2 obtained when 150 kPa load was applied. This maximum value of shear stress is greater than the maximum shear stress value of 5% gravel and laterite.

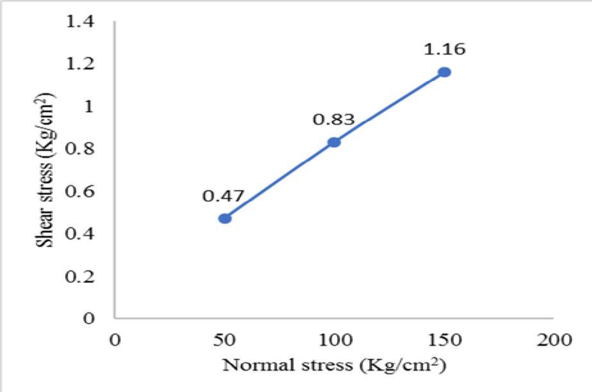

Fig. 4.11 Shear Stress Vs Normal Stress Curve For 10% Gravel + Laterite

The figure 4.12 shows the shear strain vs shear stress diagram of 15% gravel and laterite added to the sand under 50, 100 and 150 kPa loads.

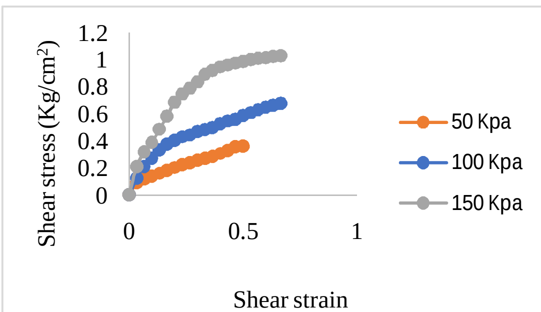

Fig. 4.12 Stress Strain Curve For 15% Gravel And Laterite

From the figure 4.13, the maximum shear stress was found as 1.03Kg/cm^2 obtained when 150 kPa load was applied. The obtained value of shear stress is less than that of 10% gravel and laterite content and greater than 5% gravel and laterite content of sand – gravel – laterite mixture.

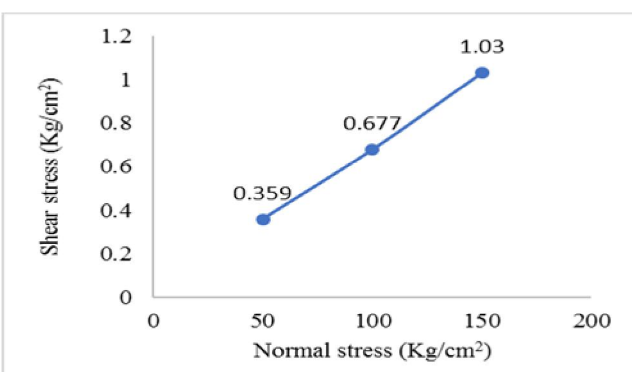

Fig. 4.13 Shear Stress Vs Normal Stress Curve For 15% Gravel + Laterite

By analyzing the experiments, it can be found that the maximum shear stress was obtained when 10% gravel and laterite content was added to the sand. Here also the maximum shear strength is obtained at 10% of gravel and laterite content. Here the laterite content act as a good binding particle between the sand and gravel than the other percentages.

The following graph (**Fig. 4.14)** shows the relationship between maximum shear stress versus percentage of gravel and laterite content in sand – gravel – laterite mixture.

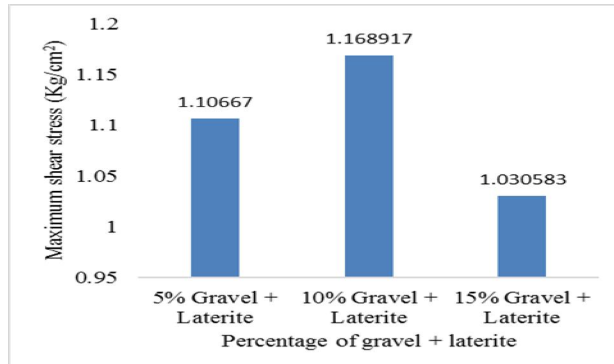

Fig. 4.14 Comparison of Maximum Shear Stress of Sand – Gravel – Laterite Mixture

From the figure 4.14, the shear stress is maximum at 10% of gravel content in the sand – gravel – laterite mixture mixture when 150 kPa load was applied. Minimum shear stress is occurred when 15% gravel and laterite content in the sand – gravel – laterite mixture.

The figure 4.15 shows the comparison of maximum shear strength values between the sand – gravel mixture and sand – gravel – laterite mixture.

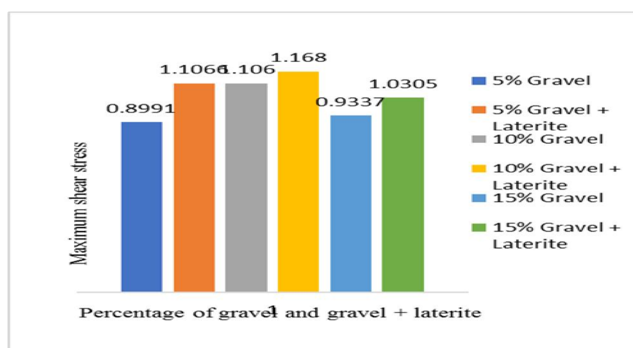

Fig. 4.15 Comparison Of Maximum Shear Stress Values Between The Sand – Gravel Mixture And Sand – Gravel – Laterite Mixture.

It is clear that, the maximum shear strength is obtained from the sand – gravel – laterite mixture. In each test, the maximum shear strength is under a loading of 150kPa and is at percentage of 10% in both sand – gravel mixture and sand – gravel – laterite mixture.

V. CONCLUSIONS

A series of direct shear tests were applied to sand - gravel and sand – gravel – laterite mixtures. The percentages of gravel and laterite added to the sand were 5%, 10% and 15%, and the results showed good potential for the application of gravel and laterite to the sand. In this experiment, by adding gravel and laterite into the sand, the shear strength of the mixtures increases than the shear strength of the sand alone. And by adding laterite to sand – gravel mixture, the shear strength of the mixture increases significantly.

- The index properties and the engineering properties of the samples were determined.
- The shear strength of the sand – gravel mixture and sand – gravel – laterite mixture was analyzed by direct shear test.
- The shear strength of the sand gravel mixture is increases with increasing gravel content up to a certain percentage of gravel and then decreases.
- The maximum shear strength of sand – gravel mixture is obtained at a gravel content of 10%.
- If the gravel content is more than 10%, then the shear strength of the sand – gravel mixture is decreases.
- The addition of laterite content to the sand – gravel mixture increases the shear strength of the sand – gravel – laterite mixture up to a certain percentage of gravel and laterite content similar to that of sand – gravel mixture.
- The maximum shear strength is occurring in sand – gravel – laterite mixture at 10% gravel and laterite content.
- The maximum shear strength value is obtained from the sand – gravel – laterite mixture than sand – gravel mixture.
- So, the sand – gravel – laterite mixture is more effective than the sand – gravel mixture as a fill material in natural slopes, engineering fills, etc.

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