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STRESS STRAIN BEHAVIOUR OF KUTTANAD CLAY MIXING WITH GRAVEL BY TRIAXIAL TESTS

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Abstract - *Kuttanad clays are dark brown colored medium sensitive alluvial deposits spread over the Kuttanad region in the state of Kerala in India. This area lies 0.6-2.2 m below mean sea level and a major portion of the region is in submerged condition during the monsoon season in every year. These clays are characterized by high compressibility, low shear strength and high percentage of organic matter, which are unfavorable from the geotechnical point of view. Gravel content is an important factor affecting the mechanical properties of clay gravel mixtures. This concept is used to improve the soil properties such as bearing capacity, shear strength etc. In this paper an attempt has been made to study the effect on the shear strength variation of soil by the inclusion of gravel. In this, the clay is being mixed with various percentages of gravel and the stress strain behavior of each sample is tested using triaxial tests.*

Key Words: Kuttanad clay, gravel, triaxial tests

1. INTRODUCTION

Kuttanad clay in Kerala, India is an important soil group, well known for its very low shear strength and high compressibility. It is a weak foundation material and has caused a number of failures to structures and embankments built over it. These soils have high proportions of organic content and are very sensitive to change in the stress system, moisture content and system chemistry of the pore fluid. In Kuttand region shear strength of the soil is less due to its very high initial moisture content and plasticity. It is an important property and is used to determine the bearing capacity of the soil.

Kuttanad clays are dark brown coloured, medium sensitive, alluvial deposit, spread over the Kuttanad region in the state of Kerala in India. The soil in this region is black or grey marine clay which has got high organic content. The dominant mineral constituents in this clay are kaolinite and illite, which have low shrink-swell capacity. These clays are characterised by high compressibility, low shear strength and high percentage of organic matter, which are unfavourable from the geotechnical point of view. The main parameter which influences the soil strength are soil plasticity and moisture content. The strength characteristics of the soil varies widely from plastic to liquid limit of the soil. At plastic limit of the soil shear strength is maximum and at liquid limit shear strength is less. The presence of clays forces the use of expensive deep foundations in these areas. Also, the settlement of foundations is a major problem associated with the structures constructed over these areas.

Clay is often taken as the material of the core of earth rockfill dam. With the increase of the height of earth rockfill dam, however, the deformation difference between core and dam shell is increasing constantly, and arch effect of stress becomes stronger. The vertical stress in the clay core is reduced significantly due to the so called arch effect, and the possibility of hydraulic fracturing of core increases. Clay core can not work reliably as a water-tight structure in high earth rockfill dam.

The concept of reinforcing soil with gravel has been widely accepted in engineering practice. This concept is used to improve the soil properties such as bearing capacity, shear strength etc. In this paper an attempt has been made to study the effect on the shear strength variation of soil by the inclusion of gravel. In this, the clay is being mixed with various percentages of gravel and the stress strain behaviour of each sample is tested using triaxial tests.

1.1 OBJECTIVE OF THE PROJECT

The objectives formulated in the study are:

1. To study the stress strain behaviour of kuttanad clay mixing with gravel by triaxial tests
2. To determine the soil sample which obtain the maximum shear strength.

2. MATERIALS AND METHODOLOGY

The soil sample was collected from pandarakullam, Alappuzha district. The sample was black coloured clay with a glowing texture. The sample was collected from a construction site from a depth of around 1m below ground level. An air tight container was taken and the sample was stored in it to determine the initial moisture content. The soil sample was collected and stored near the laboratory premises. Kuttanad clay is having low shear strength. So it is stabilized with gravel to accelerate shear strength and decrease compressibility.

Various tests were conducted on this sample to determine the index properties of soil.

The initial moisture content was found to be 112%.The specific gravity, maximum dry density and optimum moisture content was found to be 2.6, 1.18g/cc and 45% respectively. Liquid limit, plasticity index and shrinkage limit

is computed as 112.5%, 63.5% and 27.6% respectively. The soil was classified as CH, i.e., clay of high compressibility. The shear strength of soil was found to be 33kN/m^2.

Amount of gravel was a varying parameter. Different mixes were prepared by adding 10%, 20%, 30%, 40% and 50% of gravel to the clay sample. Gravel sample was having a size ranging from 4.75mm to 10mm.

3 RESULTS AND DISCUSSION

Different mixes are selected by adding gravel at percentages of 10%, 20%, 30%, 40% and 50% to the soil sample. Various tests are done to study the variation when gravel is added at varying percentages to the soil sample.

Table -1: Design mixes

MIX	PERCENTAGE OF CLAY	PERCENTAGE OF GRAVEL
GP0	100	0
GP10	90	10
GP20	80	20
GP30	70	30
GP40	60	40
GP50	50	50

3.1 DETERMINATION OF OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY

The moisture – unit weight tests conducted on raw and stabilized soil were used to determine the compaction parameters namely optimum moisture content (OMC) and maximum dry density.

Chat -1 shows the graph plotted between water content and dry density obtained after adding 50% gravel. The maximum dry density value is obtained as 2.76 g/cc which is greater than the dry density of GP0, GP10, GP20, GP30 and GP40.

The test results indicates that gravel added to the raw sample in different mix proportions leads to the increase in the maximum dry density and decrease in the optimum moisture content.

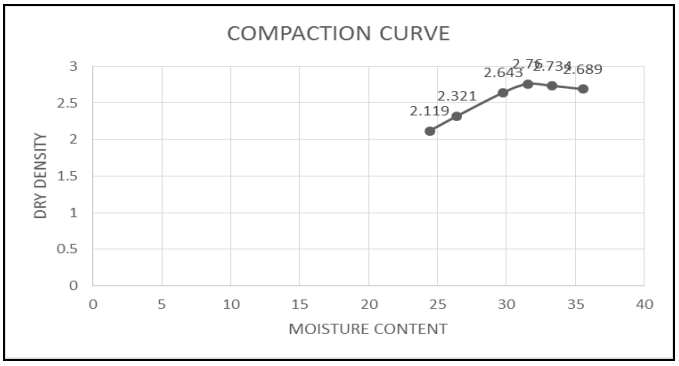

Chart -1: OMC versus MDD with 50% gravel

The optimum moisture content decreases from 45% at 0% gravel to 31% at 50% gravel addition. The maximum dry density increases from 1.18 g/cc at 0% to 2.76 g/cc at 50% of gravel addition.

Table -2: Comparison of MDD and OMC of different mixes

MIX	MAXIMUM DRY DENSITY(g/cc)	OPTIMUM MOISTURE CONTENT(%)
GP0	1.18	45
GP10	1.35	42
GP20	1.69	40
GP30	2.03	35
GP40	2.43	32
GP50	2.76	31

The addition of gravel to the clay decreases the optimum moisture content and increases the maximum dry density compared to that without gravel.

3.2 DETERMINATION OF SHEAR STRENGTH OF VARIOUS MIX PROPORTIONS

The triaxial tests conducted on raw and stabilized soil were used to determine the shear strength parameters namely Cohesion (c) and angle of friction (ϕ).

Chart -2 shows the normal and shear stress graph for mix with 50% gravel. The value of cohesion is obtained as 6KN/m^2, angle of friction as 23^{0}and shear strength as 50KN/m^2.

The shear strength value increased from 33 kN/m^2 at 0% gravel (raw sample, GP0) to 50 kN/m2 at 50% of gravel addition.

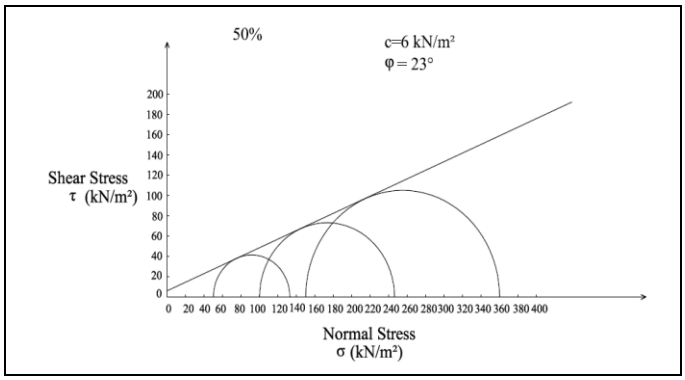

Chart -2: Normal and shear stress graph of GP50

The Shear strength values for different samples are listed out in table 3.

Table -3: Comparison of c, ϕ and shear strength of different mixes

MIX	COHESION, c (kN/m²)	ANGLE OF INTERNAL FRICTION(ϕ)	SHEAR STRENGTH (kN/m²)
GP0	9	15.5	33
GP10	10	17.3	41
GP20	9	18.8	43
GP30	8	20.6	46
GP40	7	21.8	47
GP50	6	23	50

The addition of gravel improves the strength performance of Kuttanad clay. The increase in the strength of the clay by the addition of gravel is due to the increase in the frictional strength between soil particles and gravel.

3.3 COMPARISON OF PROPERTIES OF KUTTANAD CLAY WITH AND WITHOUT GRAVEL

Chart -3 indicates that the optimum moisture content is found to decrease with addition of gravel .The moisture content for GP0 is 45% and it decreases to 31% for GP50.

Chart -4 indicates that the maximum dry density is found to increase with addition of gravel .The maximum dry density for GP0 is 1.18g/cc and it increases to 2.76g/cc for GP50.

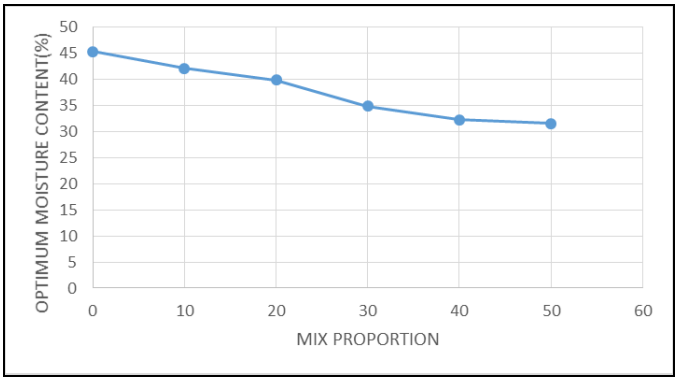

Chart -3: Comparison of OMC with various mixes

Chart -5 indicates that the shear strength is found to increase with addition of gravel .The shear strength for GP0 is 33% and it increases to 50% for GP50.

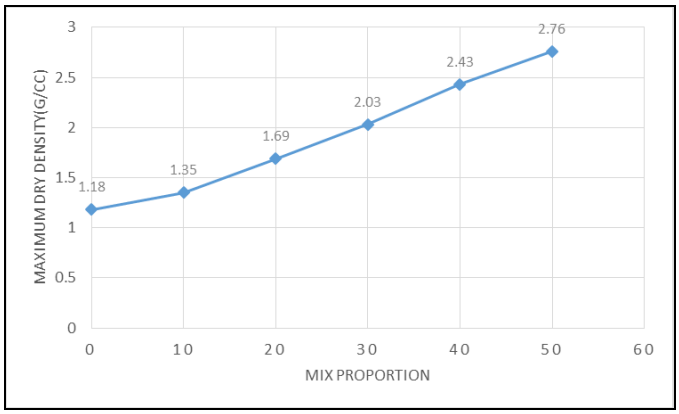

Chart -4: Comparison of MDD with various mixes

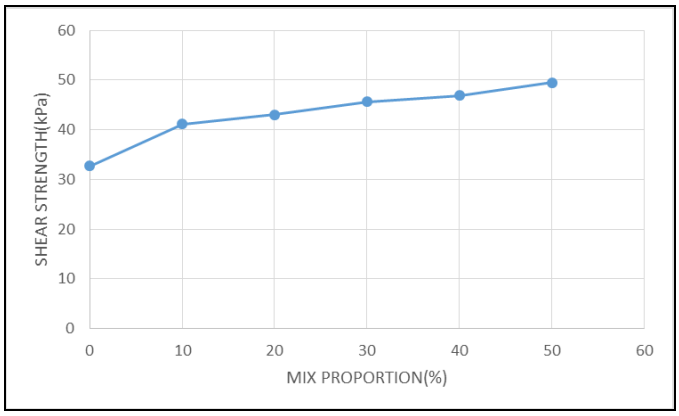

Chart -5: Comparison of shear strength various mixes

Chart -6, chart-7 and chart -8 shows the comparison of stress strain behaviour of various mixes when the cell pressure is 50KN/m², 100 KN/m² and 150 KN/m².

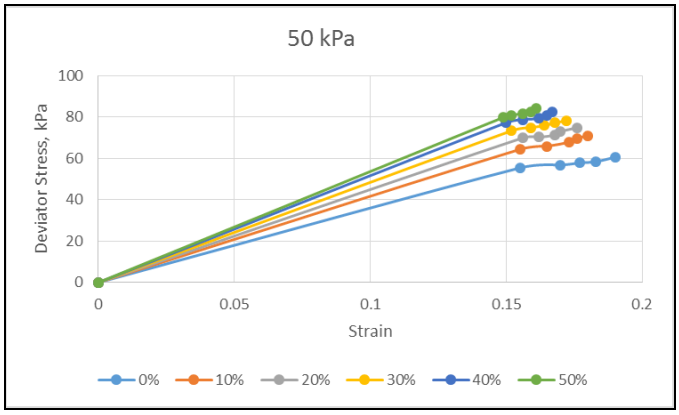

Chart -6: Comparison of stress strain behaviour of various mixes when cell pressure is 50kN/m²

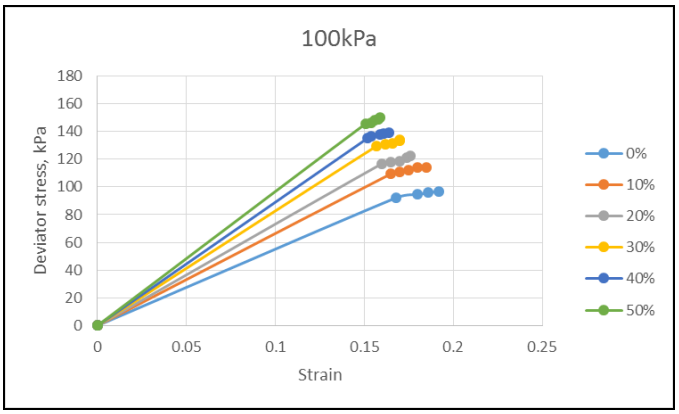

Chart -7: Comparison of stress strain behaviour of various mixes when cell pressure is 100kN/m²

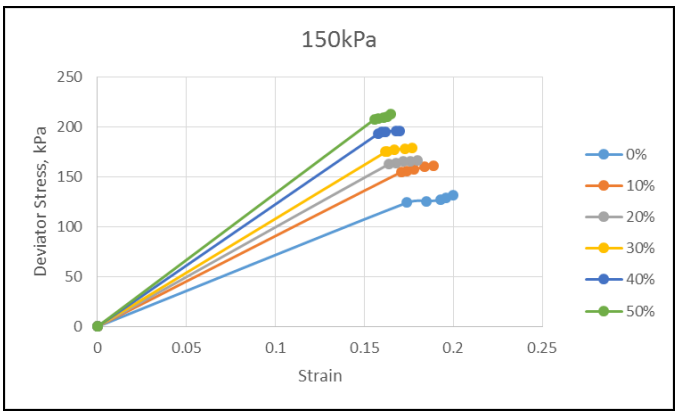

Chart -8: Comparison of stress strain behaviour of various mixes when cell pressure is 150kN/m²

It is found that the strain decreases when the gravel percentage is increased from 0% to 50% under a constant cell pressure. But for a given percentage of gravel, the strain increases when the cell pressure is increased.

4. CONCLUSIONS

After conducting the various tests, the following conclusions can be made:

- The addition of gravel to kuttanad clay is an efficient ground improvement technique.
- As the percentage of gravel increases, the maximum dry density increases and the optimum moisture content decreases. The increase in strength due to addition of gravel is because of reduction of the plastic characteristics of the kuttanad clay.
- The value of cohesion remains almost a constant upto addition of 20% of gravel and then it starts to decrease gradually.
- The angle of internal friction increases as the percentage of gravel increases.
- The shear strength of soil sample increases as the percentage of gravel increases. The increases in shear strength due to the increase in frictional strength between clay and gravel.
- For a given percentage of gravel, the strain increases as the stress increases.
- For a given confining pressure, the strain decreases as the percentage of gravel is increased.
- It is difficult to find an optimum mix as the properties of kuttanad clay goes on increasing with the addition of gravel. The addition of gravel more than 50% is uneconomical.

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