Influence of Size and Percentage of Coarse Fractions on Soil Matrix (Colluvial Deposit)

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ABSTRACT

A geotechnical investigation was conducted in Dharam Qazigund in Jammu and Kashmir for construction of number of bridges and stable slopes through the section of national highway. Determination of shear strength of soils in these regions was extremely difficult, so was the difficulty in foundation design and slope stability. Since the problem was due to the encounter with the residual soils there was failure in establishing a definite relationship between C and ϕ of the soil matrix.

As we have observed from experiments that the percentage of coarse fraction varies with respect to depth but there is no uniform trend in increase of decrease of percentage of coarse fraction along the depth. Since the determination of C and ϕ values for in situ conditions is very difficult we model the conditions of the soil matrix along with uniform or non-uniform sizes of coarse fractions and calculate parameters using large scale direct shear test machine.

Given the problematic and complex nature of soil, the soil engineering as a practical science has addressed the engineering behaviour of soil more seriously and it has taken a real commendable effort to develop unifying concept of understanding which still involves recognizing the uncertainties and applying appropriate conservation and safety factors. Further although having good sense and ability to predict and calculate the risk and behaviour of soil, the accuracy of soil science cannot be estimated and there is a need to maintain healthy scepticism in approaching geotechnical problem.

INTRODUCTION

RESIDUAL SOILS AND SOIL SCIENCE AS A COMPLEX ENGINEERING PROBLEM

Residual soils are formed when the products of rock weathering are not transported as sediments but get accumulated at the same place. If the rate of decomposition exceeds the rate of removal of the products of decomposition, an accumulation of residual soil occurs. The residual soil profile is generally in three zones, the upper zone, the intermediate zone and lastly the partially weathered zone.

The development of significant thickness of residual soils has been in many parts of the world particularly Southern Asia, Africa, North America and South America. Even though residual soils are widely spread throughout the world these soils have received relatively little study from soil mechanics experts because these soils are generally located in areas of undeveloped economics as contrasted to the transported soils which exist in most centres of population and industry.

Geotechnical or soil engineering has come a long way from its appreciated history of individual wisdom, experience or common sense to present day practical science with logical empiricism. This science has pushed its way beyond the limits of understanding the importance of customary standards of practice in spite of our instinct to show aversion to deviate too far from the criterion that has proven safe or worthy in the past.

Soil being a natural and non-manufactured material has proven itself to be one of the most potentially problematic and complex materials to tackle with. The complexity does not arise only because of soil as a material, but also by the fact that various methods to characterize the soil for various estimations of constituents, behaviour and strength are potentially difficult. It is not an exaggeration to say that soil itself may dictate appropriate technical requirement, changes and even economic feasibility. This could also be understood from the fact that the soil characterization efforts typically represent a very large share of the devoted geotechnical engineering budget. On the other hand given the practical economic constraints for the soil characterization, which though being small in extent and the limited direct knowledge of soil, the potential source of errors and need of risk calculation increases.

SCOPE AND HIGHLIGHTS

The investigations sought to characterize residual soil properties through statistical analysis of historical insitu and laboratory test records. Such analysis was undertaken due to the inherently heterogeneous nature of residual soils, their departure from the behaviour of transported soils, and the lack of specific data associated with such materials.

Many studies have confirmed that region and material specific testing is warranted for characterization of residual soils, and should be completed in preference to the adoption of generic correlations.

The study includes studying Direct Shear Parameters on different moisture content over a range of angular coarse fractions for the discussed soil sample. The study provides us with the idea of strength of residual soils and the influence of size and percentage of angular aggregates on a soil matrix.

MATERIAL

For the influence of coarse fraction on soil matrix 2 types of aggregates were used one as coarser aggregates and the other finer aggregates.

Gradation of Aggregates Sieve analysis was performed on the soil sample and the particle size distribution curve was obtained as shown in FIG 1

Particle Size Distribution Curves of Soil Sample

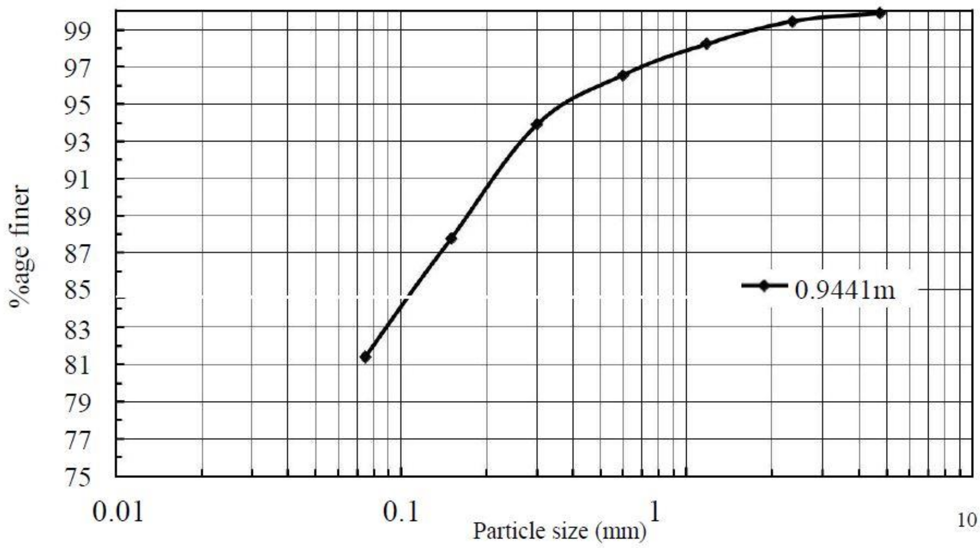

Figure 1 Sieve Analysis of Soil Sample

Various laboratory tests were performed on the soil samples and the results are summarized in Table 1

Table 1: Shows the results of experiments on material used (soil sample)

Location	Hazratbal Dargah
Depth (m)	0.9144
Bulk Density γ_b (g/cc)	1.78

Moisture Content w (%age)	19.73
Specific Gravity G	2.64173
Theoretical Dry Density γ_d (g/cc)	1.4875
Permeability k (mm/s)	3.46E-05
Coefficient of Uniformity Cu	10.83
Coefficient of Curvature Cc	1.24
Liquid Limit LL %	36.75
Plastic Limit PL %	30.19
Plasticity Index PI %	6.55894
PI (A line) %	12.2275
Flow Index IF (%)	8.26888
Toughness Index IT	0.79320
OMC (LC) %	14.1
MDD (LC) g/cc	1.81
Cohesion C DST undrained U/D (kg/cm^2)	0.22
Phi ϕ DST undrained U/D	16.699
Cohesion C DST drained U/D (kg/cm^2)	0.06
Phi ϕ DST drained U/D	12.6985
UCS qu (kg/cm^2)	0.53
Cu (kg/cm^2)	0.265
Compression Index	0.18725

METHODOLOGY

SPECIMEN PREPARATION

Soil containing gravel larger than 40mm cannot be tested unless the larger material is first removed and replaced by an equal amount of material passing the 40mm IS Sieve

Sieve sufficient quantity of soil through 40mm IS Sieve. The method of packing will depend upon the grading of material and the predominating particle size. Sands may be compacted the same way as cohesive soils if the material is large gravel, spread the sample in small lots, say 5kg in the box and compact, being careful not to form distinct layers, to give the desired density. Little guidance can be given on how much compaction is required for any particular density, this being of matter of experience and judgement.

If the soil consists of large gravel with fine materials, separate them out, pack the coarse material and blend it over with the fine sand, then compact the whole mass. Avoid forming distinct layers and ensure that a level and flush finished top surface is obtained. Scrape off the excess material using the scraper so that a 15cm thick spacemen is obtained. Position the gripper plate, perforated spacer and top loading plate. Fill the water jacket with water for saturation under a nominal seating load.

Test Procedure

Use a plain gripper plate one at bottom and one at the top of the specimen; rest the loading yoke on the ball seating of the loading plate. Fill the water jacket with water. Apply desired normal load. Each 10kg weight added to hanger gives a normal stress of.25kg/cm2 on the sample. Level the lever. Unscrew and remove the locating pins from the box. Raise the upper box over the lower one by screwing in three clearance adjustment screws by half a turn after contact with the lower box is established, and then unscrew them one complete turn. Check whether the required change gears are fixed and whether the turret setting lever is set to give the desired rate of deformation as indicated on the chart. Note all dial gauge readings.

Switch the motor on by push button. Note down the proving ring and dial gauge readings at regular intervals continue the test until the sample fails which is usually indicating by the

Reduction of the readings in proving ring dial gauge or the same readings being obtained for increased value of deformation. When the strain dial gauge plunger is nearing the end of its travel note the dial gauge reading and removes the magnetic spacer resting the dial gauge plunger against the water jacket and immediately note the readings until the maximum strain is obtained. Determine the final moisture content and density. Repeat the test for different normal loads.

The soil matrix obtained from the required site and different percentages of the coarse and fine aggregates were added separately and the resultant soil samples were subjected to direct stress under DST apparatus to find the values of C and ϕ. These values are tabulated in table 2 and 3.

Table 2: Showing the trend in values of C and ϕ for different percentages of Coarse aggregate

Sample	Coarse Aggregate %	Soil Matrix %	C Value KPa	ϕ Value
1	0	100	20	15.15
2	15	85	19	15.64
3	30	70	18	18.3
4	45	55	16	22.58
5	60	40	12	32.02
6	75	25	8	29.10
7	15	85	20	15.5

Table 3: Showing the trend in values of C and ϕ for different percentages of fine aggregate

Sample	Fine Aggregate %	Soil Matrix %	C Value KPa	ϕ Value
1	30	70	18	18.3
2	45	55	17	24.84
3	60	40	12	33.83
4	75	25	10	35.57

RESULTS

Table 4: Shows the variation Shear Stress, Cohesion & Phi for different %ages of coarse and fine aggregates

Sample			Shear Stress			Cohesion KPa	Phi ϕ Degrees
Soil%	Fine Aggregate%	Coarse Aggregate %	50 KPa	100 KPa	150 KPa		
100	0	0	30.6	44.8	52.4	20	12.41
85	0	15	31.8	49.2	59.9	19	15.64
70	0	30	33.1	57.7	67.5	18	18.2
55	0	45	35.2	63.3	78.3	16	22.5
40	0	60	41.2	80.4	105.7	12	32.01
25	0	75	38.8	79.2	104.4	9	32.4
85	15	0	32.3	52.4	60.5	20	15.4
70	30	0	34.4	59.3	68.5	19	18.26
55	45	0	38.1	67.2	86.4	17	24.8
40	60	0	42.2	89.4	112.5	12	31.6
25	75	0	39.3	84.6	106.8	10	32.6

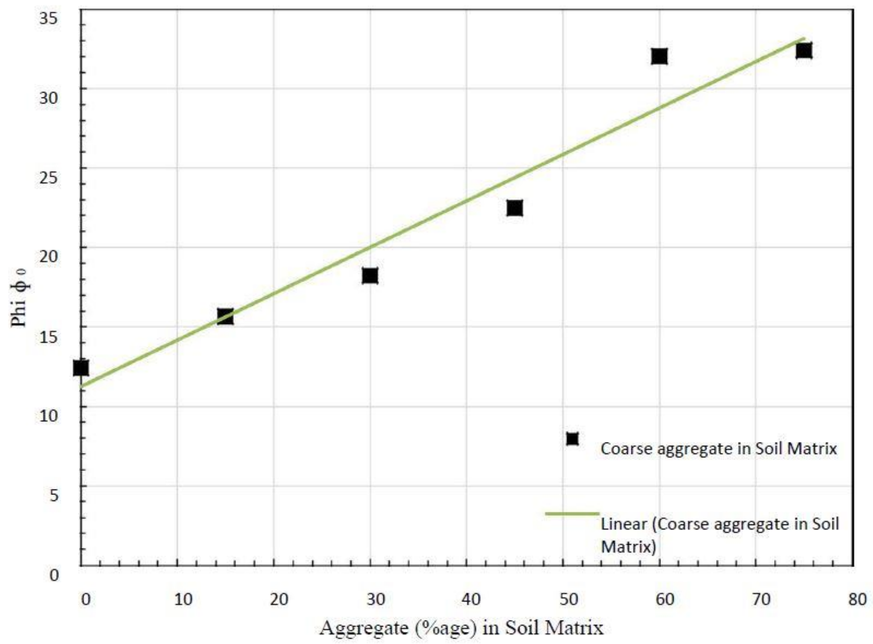

Figure 2 Plot between variation of Phi ϕ and percentage of coarse aggregates in soil matrix

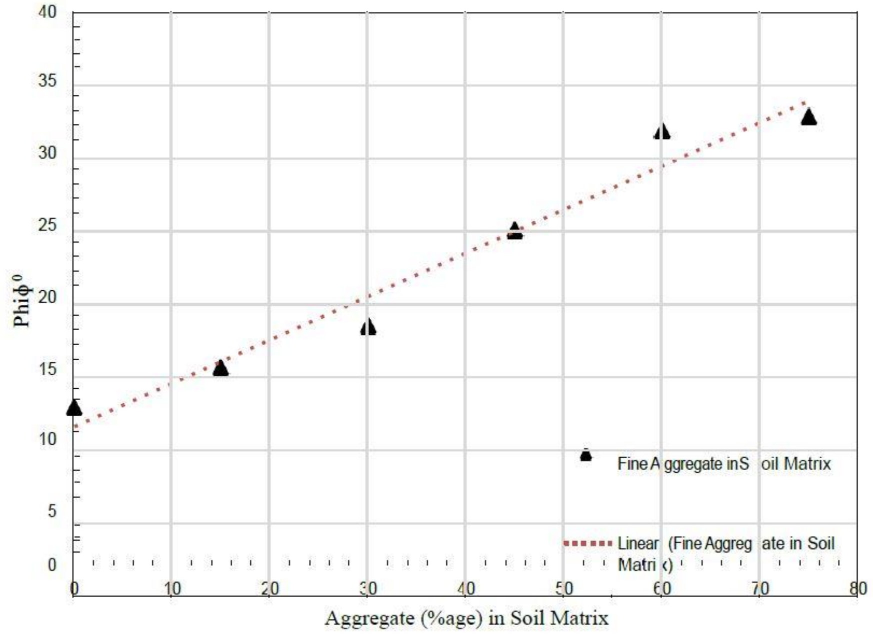

Figure 3 Plot between variation of Phi ϕ and percentage of fine aggregates in soil matrix

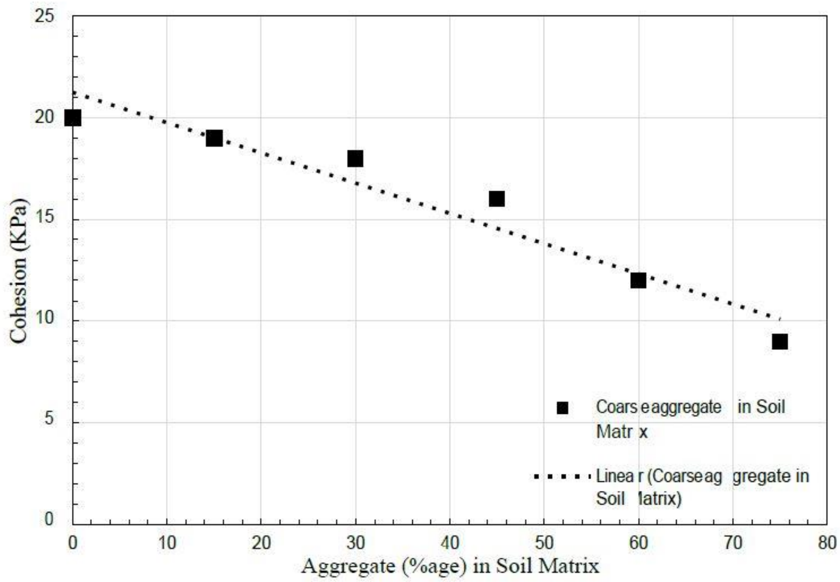

Figure 4 Plot between variation of cohesion and percentage of coarse aggregates in soil matrix

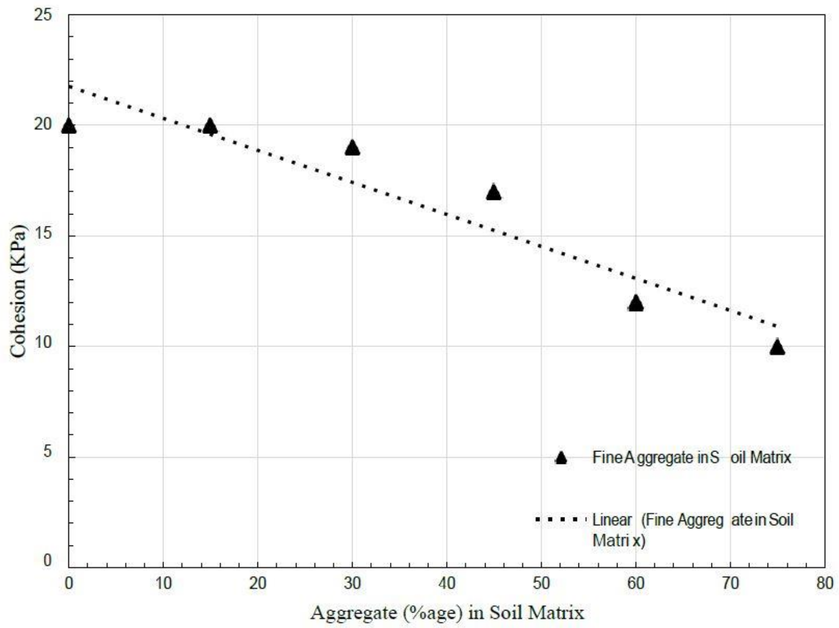

Figure 5 Plot between variation of cohesion and percentage of fine aggregates in soil matrix

CONCLUSION

1. With increase in the %age of aggregates the peak stress of the soil matrix increases up to some percentage.
2. Increasing the aggregate proportion results in the increase of angle of internal friction.
3. Increasing the aggregate proportion results in the decrease of respective cohesion
4. Higher size of aggregate results in higher value on angle of internal friction
5. Fine aggregates generate more strength as compared to coarse aggregate
6. Optimum level of both fine and coarse aggregate comes in between 60% to 75%

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