IMPACT OF RATE OF LOADING ON STRENGTH PARAMETERS OF DREDGED SOIL

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Abstract:

Strain rate has been found to be one of the prominent factors influencing the shear strength parameters of soil. In the practical world, the soils supporting various structures are subjected to varying strain rates which may be low, intermediate and high. Large-scale past experimental study on strain-rate effects on the soil concluded that the shear strength increases with increase in strain-rate. Using triaxial testing on dredged soil at varying strain rate this paper examines the impact of strain rate on strength parameters of dredged soil. Dredged soil is a solid waste generated due to dredging of Dal Lake. The Dal Lake has been the centre of Kashmir civilization and is among the most beautiful National heritages. This lake with its multi-faceted eco-system and grandeur has been inviting the attention of national and international tourists. Dredging of the Dal Lake generates the dredged soil in large quantity posing serious disposal and environmental problems all-around the Dal Lake.Concern over environmental effects of dredging, disposal of dredged soil, and the increasing unavailability of suitable disposal sites, has put pressure for characterization of this soil as a resource for various beneficial uses/engineering applications. Hence, using dredged soil has a two-fold advantage. First, to avoid the tremendous environmental problems caused by large scale dumping of dredged soil and second, to help in sustainable development of the world famous lake in the capital city Srinagar. A series of monotonic compression tests were conducted on the test soil under unconsolidated undrained conditions at three different cell pressures as 150kPa, 250kPa and 350kPa and strain rates varying from 0.24mm/min to 6mm/min. Consequently, three specimen sizes were used and were molded and tested at OMC .The undrained shear strength in this study is presented in terms of principal stress difference at failure (σ_1- $\sigma_{3)f.}$ The specimen is sheared at a particular strain rate and the load readings are taken for a set of deformation readings. The proving ring readings are taken until failure or 20% of axial strain. It was observed that value of deviator stress at failure is more at higher strain rate. It was also observed from the test results that value of deviator stress at failure is more for smaller specimen size.

Keywords: Dredged soil, Strain-Rate, Specimen size, Optimum Moisture Content (OMC),Monotonic Triaxial Compression Test, Deviator stress at failure.

I. INTRODUCTION

The Kashmir valley is gifted with exotic natural scenic beauty of landscape and water bodies, which are of great ecological and socio-economic significance. Out of them, the most famous are Dal Lake, Wular Lake, Nigeen Lake. Dredged soil is a solid waste generated due to dredging of these Lakes. Dredging of these Lakes generate dredged material in bulk from various basins. The issues surrounding the disposal of this very large quantity of material will have a significant impact on both economic developments in the region and the environment. Current plans are to dispose of the uncontaminated sediments from these lakes either on shoreline of Lake or in filling low lying areas surrounding the Lake, both of which face opposition from environmental groups and local fishermen. The movement of large volumes of sediment from one location to another disrupts existing 'habitats' at both the dredging location and the disposal site. Concern over environmental effects of dredging, disposal of dredged material, and the increasing unavailability of suitable disposal sites, has put pressure for characterization of this material as a resource for various beneficial uses/engineering applications. Its mineralogy and Geotechnical properties qualify it for use in the manufacture of high value, beneficial use products. In some parts of the world, dredging to obtain construction material is a common practice. Because of the growing demand for construction materials and dwindling inland resources, this may be an important beneficial use.

The rate of strain is defined as the rate at which the distances of adjacent particles of materials change with time. It is the time rate of change of strain. The rate of loading or strain rate has been found to be one of the prominent factors influencing the shear strength parameters of soil. The shear strength of soil is of special relevance amongst various geotechnical soil properties and it is one of the most essential entities for analyzing and solving different stability problems such as evaluation of earth pressure, bearing capacity of footings and foundations, earth quick analysis of structures and slope stability or stability of embankments and earth dams. Shear strength of soil describes the maximum shear stress that a soil can sustain in its incipient failure condition. In the practical world, the soils supporting various structures are subjected to varying strain rates which may be low, intermediate and high.

For example,

- During monotonic loading, low strain rates are generated.
- During moderate traffic conditions or during gatherings, intermediate strain rates are generated.
- During earthquakes or heavy rains, high strain rates are generated.

II. MATERIALS

The soil selected for purpose of this study was collected from the Dal basin viz Shalimar area of Jammu and Kashmir. The soil was a dredged material from "Dal'' which is a lake in Srinagar, the summer capital of Jammu and Kashmir. The urban lake, which is the second largest in the state, is integral to tourism and recreation in Kashmir and is named as "jewel in the crown of Kashmir" or "Srinagar's Jewel''. The movement of large volumes of sediment into Dal lake generates dredged material in bulk from various basins. This material can be a valuable resource for many practical purposes. Depending on the type of environment, the excavated material may comprise of gravel, sand , silt or soft clays. On the basis of its characterization, it may be put to various uses such as foundation material, subgrade construction , reclamation, landscaping, agriculture , covers for landfills and constructing wetlands for water quality improvement , bank stabilization , and creation of islands, wildlife habitat wetlands and amongst others.

III. METHODOLOGY

Two series of tests were carried out in this work. The first series of tests aimed at evaluating the physical, index and engineering properties of dredged soil. In the second series of tests, triaxial compression tests under unconsolidated undrained conditions were carried out to evaluate the impact of strain rate on various strength parameters of test soil.

IV. EXPERIMENTAL RESULTS AND INTERPRETATION

Influence of strain-rate on deviator stress at failure.

The variation of deviator stress for specimen size of dia 75mm, 50mm and 38mm with varying strain rate at optimum moisture content is shown in fig 1, 2 and 3 respectively. The principal stress difference $(\sigma_1 - \sigma_3) = \sigma_d$, is plotted as a function of axial strain for three different specimen sizes at three different strain rates. It is observed that with increasing strain rate , an increase in failure deviator stress occurs. The value of deviator stress at failure is maximum for highest strain rate (6mm/min, in this case) and minimum for lowest one (i.e., 0.24 mm/min).

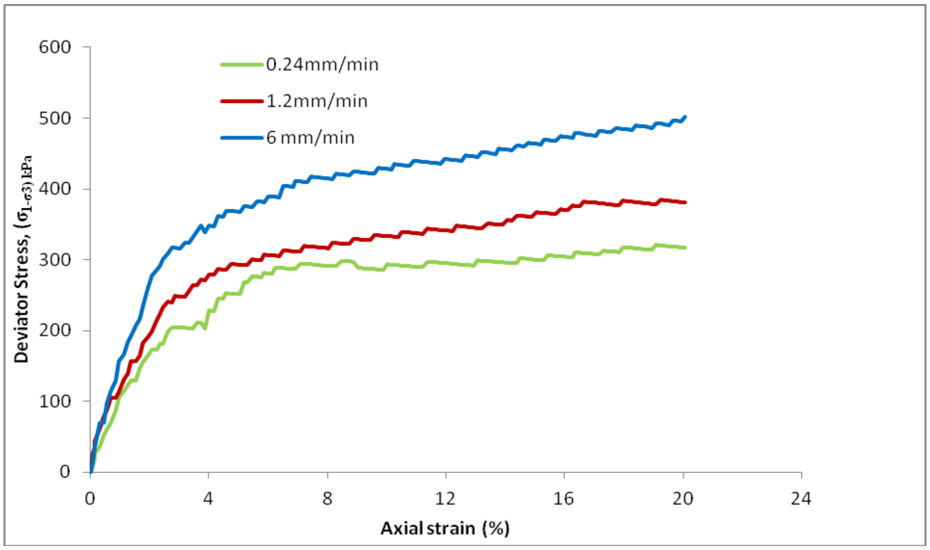

Figure1: Results from UU triaxial compression tests on soil with same sample size (Dia= 75mm) but different strain rates (Each curve is obtained at σ_3 = 350kPa).

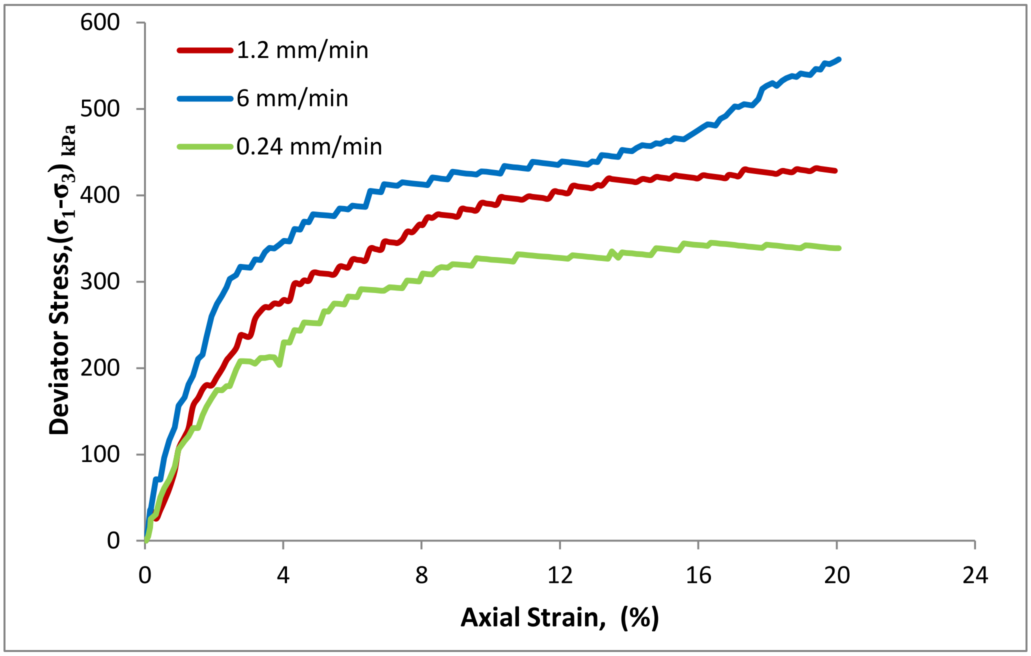

Figure2: Results from UU triaxial compression tests on soil with same sample size (Dia= 50mm) but different strain rates (Each curve is obtained at σ_3 = 350kPa).

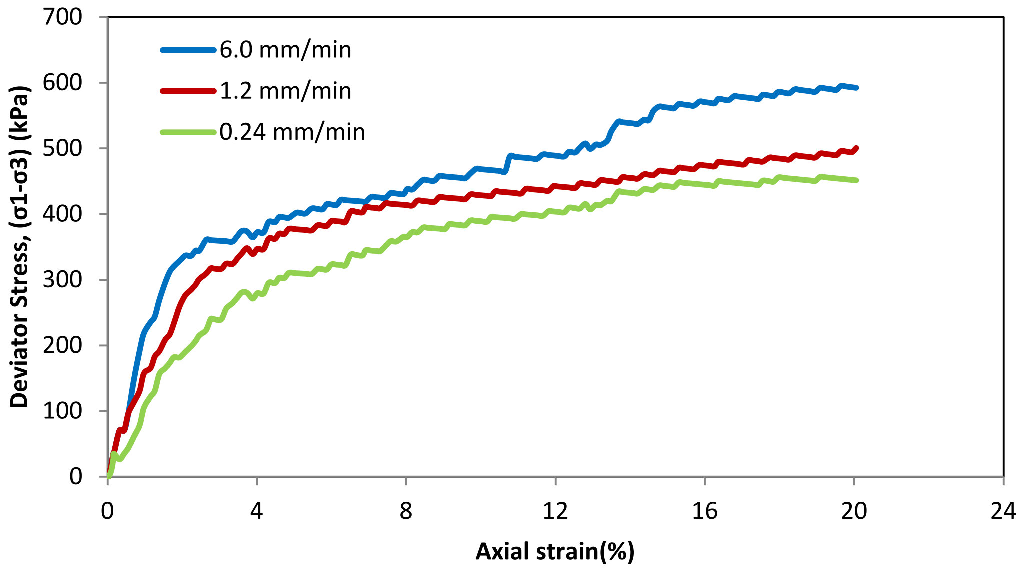

Figure3: Results from UU triaxial compression tests on soil with same sample size (Dia= 38mm) but different strain rates (Each curve is obtained at σ_3 = 350kPa).

Influence of Specimen Size on Deviator Stress at Failure

The influence of sample size (diameter) on the undrained deviator stress is shown in Figure 4. Deviator stress mobilized is constantly larger in smaller specimens. The 38mm specimen shows the higher value of deviator stress at failure than 75 mm specimen. Similarly, 50mm specimen shows the higher value of deviator stress at failure than 75 mm specimen.

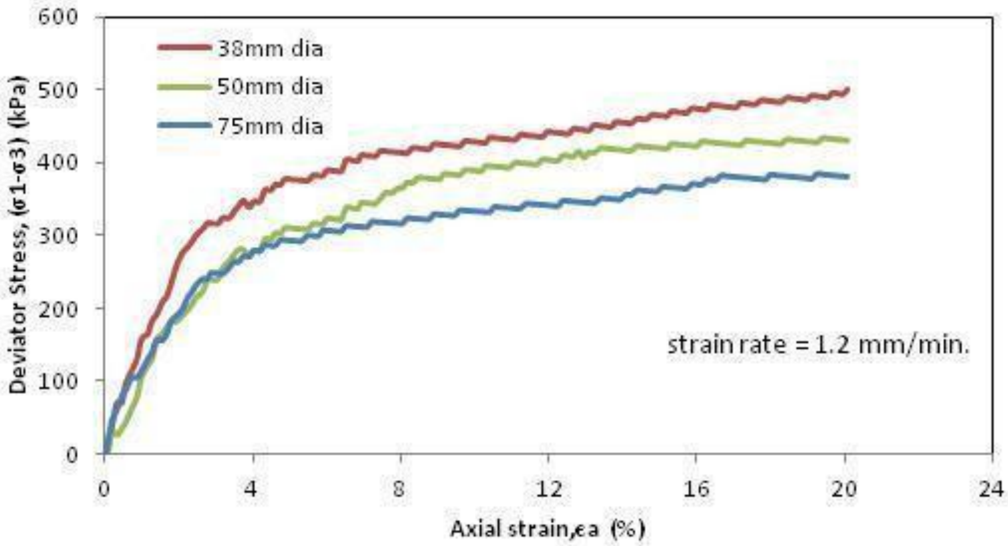

Figure 4: Results from UU triaxial compression tests on soil for three different specimen sizes at same strain rate (1.2 mm/min).(Each curve is obtained at σ_3 = 350kPa) .

V. CONCLUSION.

The following conclusions can be drawn from the experimental results:

- The variation of strain rate results in the variation of the shear strength of soil. An increase in $(\sigma_1 - \sigma_3)_f$ with an increasing strain rate was observed in the stress- strain curves. The maximum value for $(\sigma_1 - \sigma_3)_f$ was observed for highest strain rate (6mm/min, in this case) and minimum value for lowest strain rate (i.e. 0.24 mm/min).
- The deviator stress mobilized throughout the tests is consistently larger in the smaller specimens and deviator stress at failure increases with decreasing specimen size. The deviator stress for larger specimen (75mm dia) was found minimum that that for smaller specimen (38mm).
- On the basis of these tests, it must be concluded that to obtain significant increase in strength it takes a rate of strain equivalent to a fast transient test.

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