A Laboratory Study on the Mechanical Behaviour of Dredged Soil Admixed with Waste Rubber Tyre Powder and Cement

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Abstract. Due to the rapid development in automobile industry, the amount of tyre wastes has been increasing every year throughout the world. An attractive method to reduce the tyre waste produced is the use of recycled waste materials for civil engineering application and also it may be used as a stabilizer in soils so that it may help in improving the engineering properties of soft soil. Dredge material which belongs to soft soil deposits usually have low bearing capacity, high compressibility and undergo settlement over a long period of time, hence cannot be used as a construction or foundation material. Hence, in this study tyre rubber powder has been used to see its influence on the mechanical properties of Dredged soil. In this study, dredged soil was collected from the catchment of Dal Lake- Nishat. Various tests like specific gravity, gradation analysis, Atterberg's limit, compaction tests, direct shear tests, unconfined compressive strength, California bearing ratio tests have been done in order to characterize and find the shear strength parameters. The future scope of study involves performing compaction test and UCS on the soil incorporated with rubber powder (passing 425µ) at varying percentages of 1.5%, 3%, 4.5%, 6%, 9%, 12% and 15%. Also, to further improve the strength, cement at a constant percentage (2%) is added to rubberized soil and the effect of using rubber powder and cement (2%) on UCS characteristics of dredged soil at various percentages by curing the sample at 3 days and 7days is to be analyzed.

Keywords: Tyre Rubber powder, Cement, Dredged Soil, Unconfined compressive strength.

1 Introduction

Due to the rapid urbanization and population explosion particularly in developing countries, there is shortage of construction materials as well as scarcity of suitable construction sites. Thus, it forces the geotechnical engineers and specialists to adopt such soft soil sites for construction. Soft soil deposits which are very weak having low bearing capacity and undergo settlement for a considerable period of time. To assess the mechanical behavior of such soils, Geotechnical engineers face a difficult task (Mir 2017). Using these spoils as construction material, foundation medium, backfill, in dykes and embankments (Aarninkhof and Luijendijk 2010; Mir and Mir 2004) becomes a substantial problem for geotechnical engineers. This study deals with waste material generated by dredging the world famous Dal Lake. Dal Lake in Srinagar, Jammu & Kashmir, India, is the second largest Lake in state and has been integral to tourism and recreation in Kashmir The Lake receives large quantity of sediments and nutrients with the runoff from its catchment during the downward movement of water from Marsar. A large amount of sewage from the settlements around the Lake and the habitation living on hamlets within the Lake, on floating islands and houseboats enters the Lake without treatment. Huge quantity of solid wastes and superfluous fertilizers from inlet channels produces algal blooms which ultimately results in eutrophication. In September 2014, the massive flood which occurred when the river Jhelum rose to the dangerous level due to intense rainfall from 1st to 7th of September 2014, a huge amount of water entered the Dal Lake due to breech in embankment at Ram Munshi Bagh. This water brought large amount of silt and biological load in the Lake, thus causing siltation and pollution of Dal. As a result of this continuous disposal of wastes, silt deposition and encroachment, the load carrying capacity of the Lake has been reduced. So, it becomes necessary to carry out dredging of this lake.

On the other hand, with the change in living style and attitude of people there is increase in number of automobiles, the kilometer coverage by the vehicles is also increasing. All this resulting in increased demand of tires as original equipment and as replacement has also increased. About 1.1 million all types of new vehicles are added each year to the Indian roads. As a result, large quantity of waste tyres is produced. The disposal of these used tires has become a global problem due to problems associated with conventional landfill disposal methods. Most of the times, tires are being dumped on ground or added to garbage create environmental and health problems. There are possibilities of using these tires in civil engineering applications such as highway embankments and backfills behind retaining structures over weak or compressible soils. The reclamation and recycling of waste rubber has been reviewed extensively in Adhikari and Maiti (2000).Many researchers have assessed some fundamental engineering properties of tyre crumb soil mixtures, such as compaction characteristics, compressibility, and permeability, shear strength, modulus of elasticity, and Poisson's ratio (Humphrey and Manion 1992; Edil and Bosscher 1994). Jan et al. (2015) found that maximum dry density and optimum moisture content of clayey soil gets decreased as the percentage of rubber gets increased. Researchers like Hambirao and Rakaraddi (2014) found that unconfined compressive strength of black cotton soils gets increased upto optimum rubber content, after incorporating rubber powder in varying percentages.

2 Material and Methods

2.1 Materials

In the present investigation, samples of dredged soil have been collected from Dal Lake- Nishat. At the site, samples were sealed and transported in polythene bags for studying various in-situ properties.

2.2 Testing Methodology

Various laboratory tests on soil sample like gradation, consistency, Atterberg’s limits, unconfined compression test, direct shear test, California bearing ratio test have been done. After this, crumb rubber of size passing 425micron was added into the soil at percentages like 1.5%, 3%, 4.5%, 6%, 9%, 12% and 15%. The properties of dredged soil having done as per relevant IS codes are listed below.

3 Results and Discussions

3.1 Compaction Tests

Standard Proctor compaction tests were conducted on the various combinations of clay-cement-rubber fibre as shown in to determine their maximum dry unit weight and optimum moisture content. The results obtained from various combinations of rubber cement and soil are shown in Fig.1.The results revealed that as the percentage of rubber increases from 0 to 15%, maximum dry density of soil got decreased and also optimum moisture content got decreased , although it varies over a narrow range. The decrease in MDD of the soil may be attributed to low specific gravity of soil(1.15) and reason for decrease in OMC of soil may be due to the low water absorption of soil (Yadav and Tiwari 2017; Signes et al. (2016)). On the other hand, when cement at a constant percentage of 2 % was added to rubberized soil mixtures, MDD of the soil got increased upto an optimum rubber percentage of 6% and beyond that it decreases as shown in Fig. 2. Also, the addition of cement decreases the optimum moisture content of rubberized soil. This increase in maximum dry unit weight upon addition of 2 % cement of rubberized soil, upto rubber content of 6% is due to the higher specific gravity of cement compared to rubber and soil. The decrement in optimum moisture content may be due to the low water absorption capacity of rubber fibres (Kalkan 2013) and also due to alteration in particle size distribution upon addition of cement (Jan and Mir 2018).

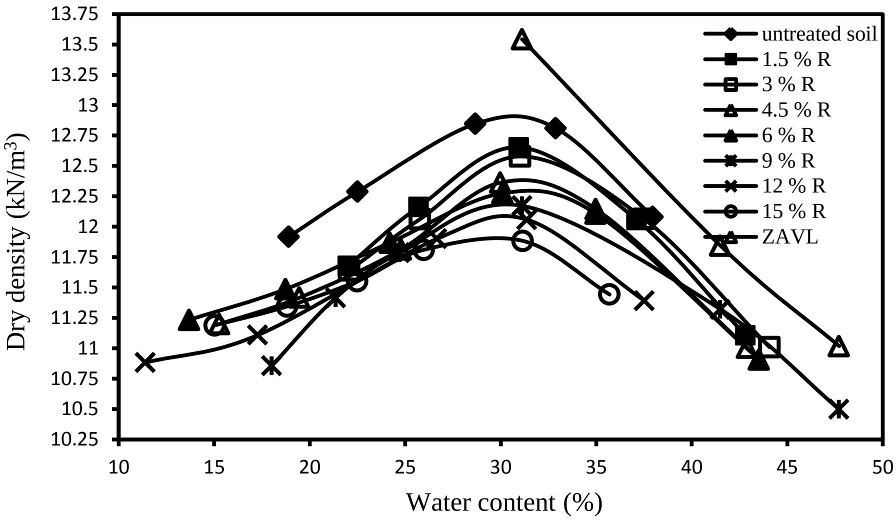

Fig. 1. Compaction curves for crumb rubber stabilized dredged soil.

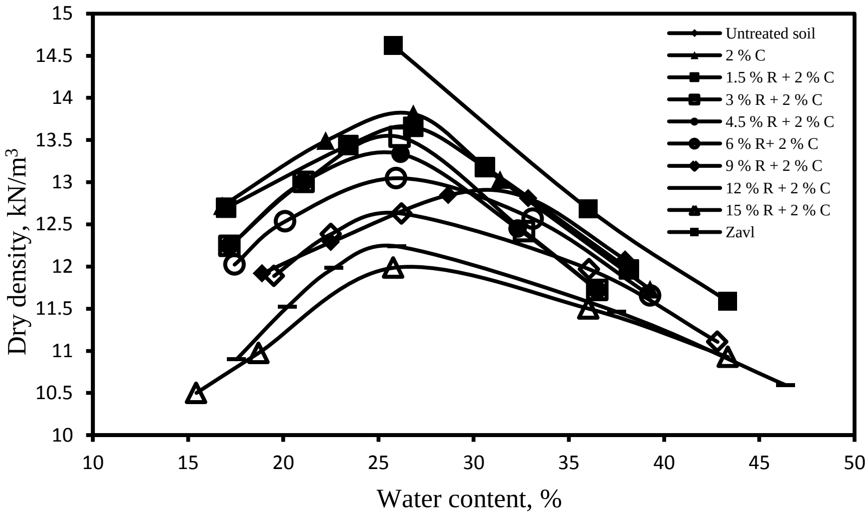

Fig. 2. Compaction curves for cement stabilized rubberized dredged soil

3.2 Unconfined Compressive Strength

Unconfined compression test is the simplest and quickest method to determine the shear strength of cohesive soils. Test specimens were prepared, compacted under standard compaction at γ_{dmax} and optimum moisture content. The samples were tested immediately, 3 days and 7 days, of curing. Test results revealed that as the percentage of crumb rubber increased as shown in Fig. 3, axial stress of soil increases upto an optimum rubber value of 4.5%, beyond which it got decreased (Srivastava et al.

2014).The decrease in axial stress of soil may be attributed to the elastic nature of rubber which shows pronounced effect after its optimum value. The failure strain of normal soil is 4.5 %, which increases to 8.6 % with the inclusion of 15% rubber fibres. The increase in the axial strain of soil–crumb rubber specimens corresponding to the failure axial stress may be accredited to elastic reaction generated by the rubber tyre during compression results into prevention against generation of cracks (Yoshio et al. 2008).

Also, it can be inferred from the results as shown in Fig. 4 that with the increase of the cement content in the rubberized soil, the peak axial stress increases upto rubber fiber content of 4.5 %. The peak axial stress of cemented rubberized specimens increases as compared to the uncemented samples. The significant improvement in the peak axial stress may be due to cementation reactions. From Fig. 5 and Fig. 6 it is inferred that curing time also increases the strength with cement content and may be due to the formation of secondary cementitious products.

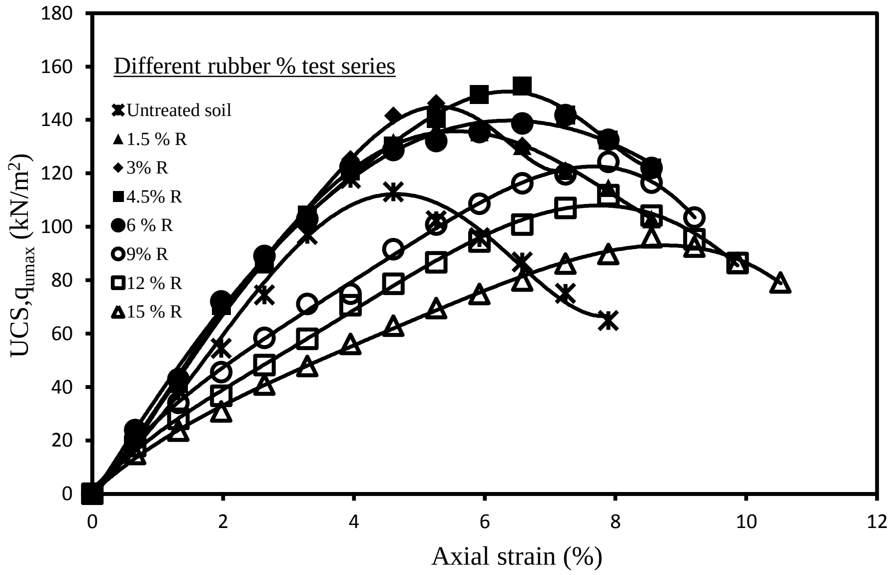

Fig. 3. Stress strain curves for rubber stabilized dredged soil

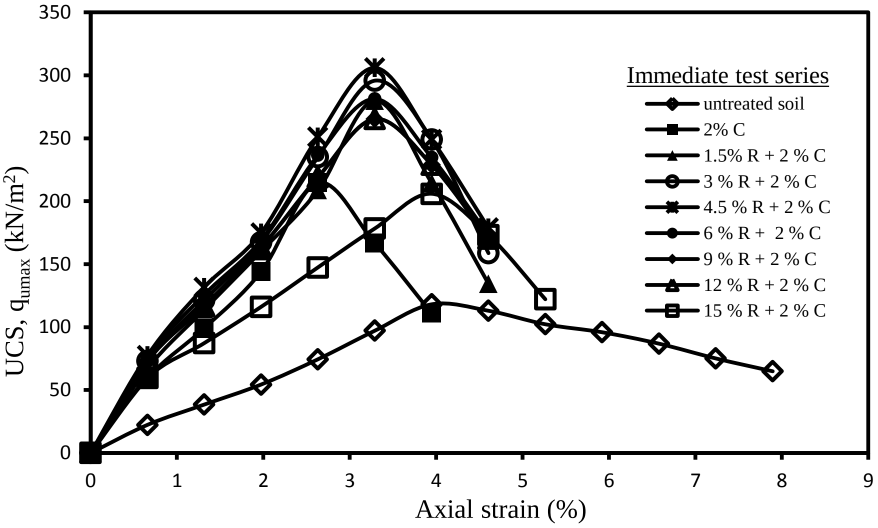

Fig. 4. Stress strain curves for cement added rubberized dredged soil (0 day)

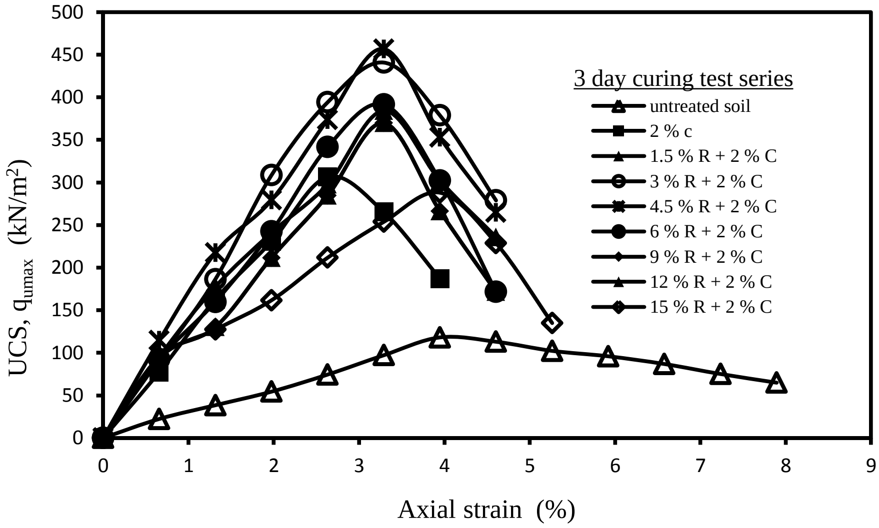

Fig. 5. Stress strain curves for cement added rubberized dredged soil (3 day)

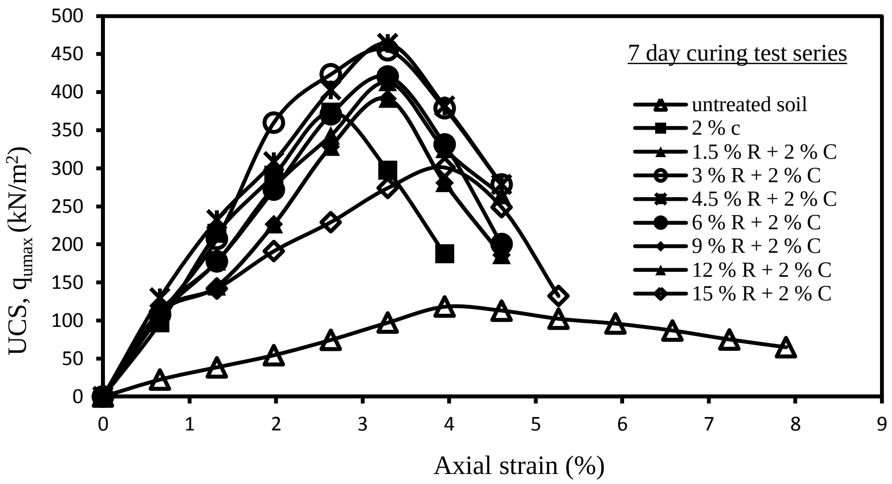

Fig. 6. Stress strain curves for cement added rubberized dredged soil (7 day)

4 Conclusion

On the basis of this investigation, following conclusions can be made:

1. Dredged material consists of poorly graded inorganic silt of medium plasticity with poor fill material characteristics
2. Dredged material under investigation possesses medium to high compressibility with high rate of loss of shear strength
3. Maximum dry unit weight and optimum moisture content of dredged soil decreased as the content of crumb rubber in the mixture increases
4. The UCS test result indicated that the addition of crumb rubber upto optimum value of 4.5 % in the soil marginally improves the shear strength. However, axial strain corresponding to failure increases as the percentage of crumb rubber increases. The addition of cement increases the UCS of the soil dramatically but induces brittleness in the composite
5. The curing period increases the inter particle bonding due to pozzolanic reactions that take place by the formation of cementitious compounds

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