A Study of Combined Mechanical and Chemical Stabilisation of Fine Grained Dredge Soil of River Jhelum

Adnan F. Sheikh, Fayaz A. Mir

***Abstract*—**After the recent devastating flood in Kashmir in 2014, dredging of the local water bodies, especially Jhelum River has become a priority for the government. Local government under the project name of 'Comprehensive Flood Management Programme' plans to undertake an increase in discharge of existing flood channels by removal of encroachments and acquisition of additional land, dredging and other works of the water bodies. The total quantity of soil to be dredged will be 16.15 lac cumecs. Dredged soil is a major component that would result from the project which requires disposal/utilization. This study analyses the effect of cement and sand on the engineering properties of soil. The tests were conducted with variable additions of sand (10%, 20% and 30%), whereas cement was added at 12%. Samples with following compositions: soil-cement (12%) and soil-sand (30%) were tested as well. Laboratory experiments were conducted to determine the engineering characteristics of soil, i.e., compaction, strength, and CBR characteristics. The strength characteristics of the soil were determined by unconfined compressive strength test and direct shear test. Unconfined compressive strength of the soil was tested immediately and for a curing period of seven days. CBR test was performed for unsoaked, soaked (worst condition- 4 days) and cured (4 days) samples.

***Keywords*—**Comprehensive flood management programme, dredge soil, strength characteristics, flood.

I. INTRODUCTION

DREDGED soil has very low bearing capacity and is an environmental nuisance due to lack of suitable dumping sites. Among various chemical stabilization methods, cement stabilization can be used to improve the properties of marginal/weak soils to provide a workable platform for construction of various infrastructure projects [1]. Many researchers have documented the beneficial effect of cement on the performance of soils. However, the findings of different researchers on the role of Portland cement on compacted properties and strength is not consistent. Some researchers [2] reported cement treatment increased cohesion while internal friction remained constant, while others [7] stated that internal friction improved considerably. The transition of failure type from ductile in virgin soil to brittle is due to the presence of cement and sand.

The study has been undertaken to explore the possibility of stabilizing dredged soil using a combination of cement and sand.

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II. MATERIALS AND METHODS

Dredged soil of river Jhelum from the Eidgah Palpora area of Srinagar city was collected. The dredged soil sample was oven dried and sieved through a 4.75 mm sieve. Virgin soil properties like gradation, consistency parameters, and strength characteristics were determined. Ordinary Portland cement (OPC) and sand were used to prepare the specimen in the study. The cement concentration was kept at 12%, which is suitable for silts [6]. OPC of 43 grade, fineness 2% and consistency 31% was packed in 1 kg to 2 kg polythene bags and kept in air tight containers to preserve freshness. The tests on properties of cement were done in accordance to [4].

CBR samples for four days curing were prepared by simulation of wet sacks, which were wrapped around the mould, which was then shifted into an air tight container to prevent loss of moisture. Cured UCS samples were prepared and placed in a dessicator for seven days. The test procedures were followed in accordance to [3].

III. RESULTS AND DISCUSSION

Virgin soil properties were analysed and the soil sample was found to be weak. The soil is low plastic (IP=6.95). Inactive with an activity number of 0.72 and of medium consistency (qumax (kPa)=78.95)

A. Effect of Cement and Sand on Compaction Characteristics of Soil

The treated samples exhibit a gentle compaction curve barring sample with addition of sand (30%) only (Fig. 1). The maximum dry density increases, but the optimum moisture content decreases because coarser soils require lesser moisture content to obtain the maximum dry density. The dry density of the mix increased due to better packing together of soil and sand particles leading to the well-graded nature of the mix and specific gravity of sand being more. Other samples show a wide and gentle slope which provides a wide range of moisture contents to achieve the desired dry density

B. Effect of Cement and Sand on Unconfined Compressive Strength of Soil

Test specimens were prepared, compacted under standard compaction at γ_{dmax} and optimum moisture content. The samples were tested immediately and for a curing period of seven days (Figs. 2 and 3). The test results revealed that addition of cement and sand has significant effect on the strength gain of the dredged soil. Maximum strength gain occurs in soil + cement (12%) + sand (30%) with considerable improvement in unconfined compressive strength ($q_{u\ max}$). Curing period (7-days) increased the strength of the dredged soil to 1707 kPa from 78.97 kPa. The sample with admixture addition shows high brittleness and should be used with care in the field.

TABLE I
VIRGIN SOIL PROPERTIES

Properties	Value
Specific gravity, G	2.61
Clay (%)	9.70
Silt (%)	89.51
Sand (%)	0.525
Gravel (%)	0.265
Liquid limit (%)	34.82
Plastic limit (%)	27.87
Shrinkage limit (%)	15.3
Plasticity Index (%)	6.95
Plasticity Index-A-Line (%)	10.82
Plasticity Index-U-line (%)	24.14
Activity	0.72
Soil type and classification	ML
Clay mineral	Kaolinite
Flow Index, I_f (%)	17.16
Toughness Index, I_t(%)	0.41
Coefficient of uniformity, C_u	9
Coefficient of curvature, C_c	2.01
Consistency Index, I_c(%)	1.87
Liquidity Index, I_l (%)	98.12
Suitability number	917
Natural moisture content (%)	34.69
Maximum dry density(kPa)	15.87
Optimum moisture content (%)	23.69
Cohesion(kPa)	24.03
Angle of friction, ø (deg)	24.41
CBR (Unsoaked)	2.78
CBR (soaked)	1.215

C. Direct Shear Test

The test results revealed that the addition of cement and sand has significant effect on the cohesion and angle of internal friction of the dredged soil. Maximum increase occurs in soil + cement (12%) + sand (30%) with considerable improvement in c (kPa) and ϕ (deg) parameters of soil. Cohesion increased to 62.77 kPa and angle of internal friction to 35.6^0 from 24.03 kPa and 24.41^0, respectively. It is observed that the cohesion improves significantly as compared to angle of friction.

1) California Bearing Ratio Test

Maximum improvement was recorded in soil + cement (12%) with an increase in CBR to 18.75% from 2.78% in unsoaked condition and 71.53% from 1.22% in soaked condition (worst condition-4 days) (Table III). The cured samples show less improvement due to lesser curing time. The CBR sample in cured and soaked condition attains high strength. As the cement hydrates, the mixture becomes hard, durable structural material. Hardened soil cement has the capacity to bridge over local weak points of subgrade. When properly made, it does not soften when exposed to wetting and drying or freezing and thawing cycles [5].

TABLE II
VARIATION OF MAX DRY DENSITY AND OPTIMUM MOISTURE CONTENT

Type of soil	OMC (%)	MDD(kN/m^3)
Untreated soil	23.69	15.87
Treated soil		
Soil+cement (12%) + sand (10%)	21	16.57
Soil+cement (12%) + sand (20%)	20.10	17.02
Soil+cement (12%) + sand (30%)	18.26	17.13
Soil+cement (12%)	19.93	16.39
Soil+sand (30%)	15.84	18.05

TABLE III
VARIATION OF CBR

	CBR (%)		
Type of soil	Unsoaked	Soaked	Cured
Untreated	2.78	1.215	N.P
Treated			
Soil+cement (12%) + sand (10%)	6.94	53.56	53.47
Soil+cement (12%) + sand (20%)	17.882	63.368	55.208
Soil+cement (12%) + sand (30%)	18.576	66.146	56.076
Soil+cement (12%)	18.75	71.53	54.340
Soil+sand (30%)	7.29	3.3	N.P

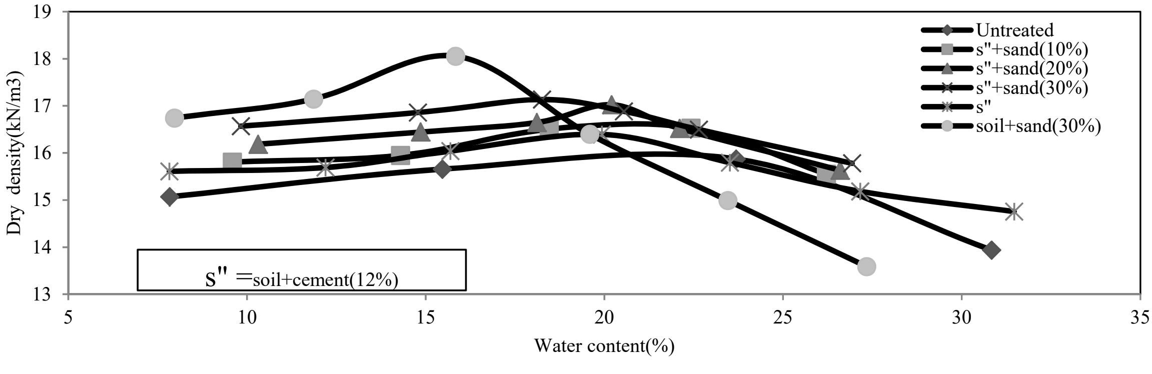

Fig. 1 Compaction characteristics of soil samples

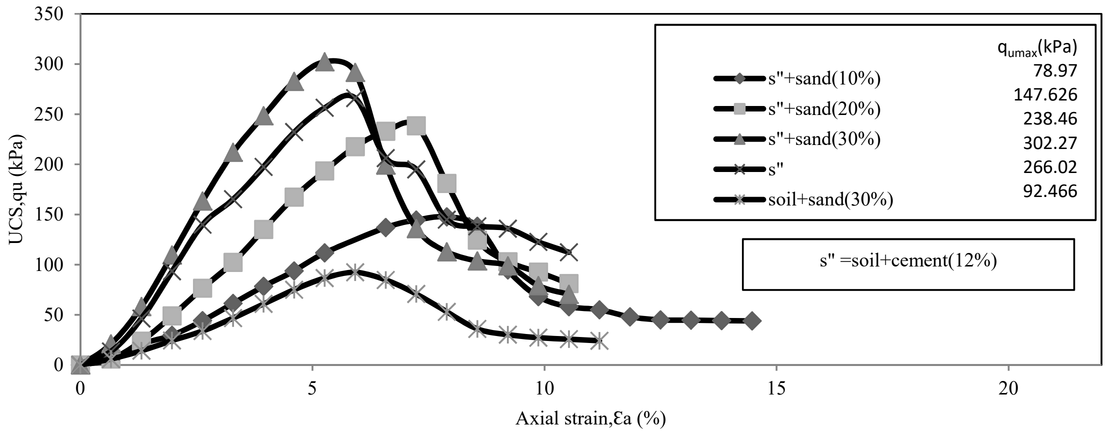

Fig. 2 Variation of unconfined compressive strength (Immediate)

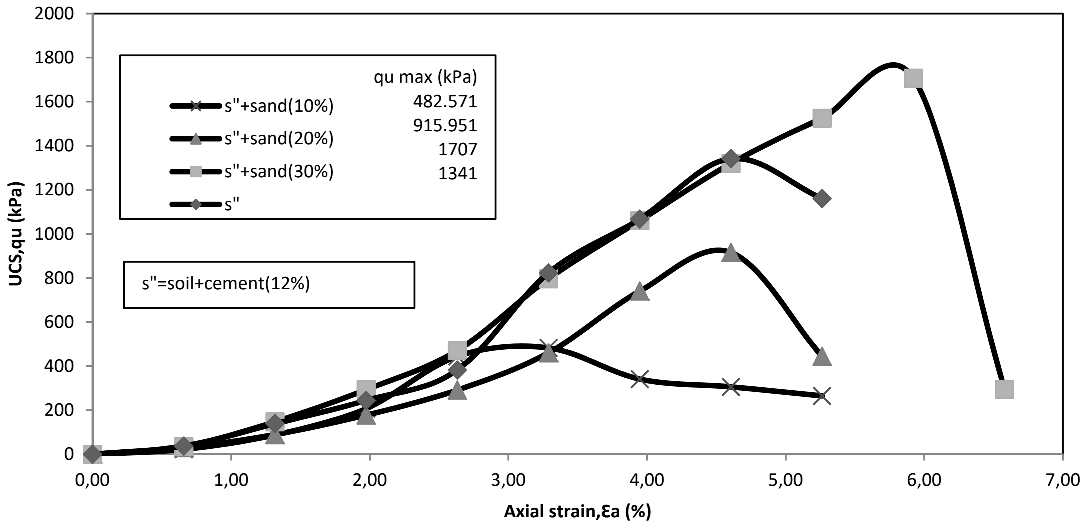

Fig. 3 Variation of unconfined compressive strength (Cured-7 Days)

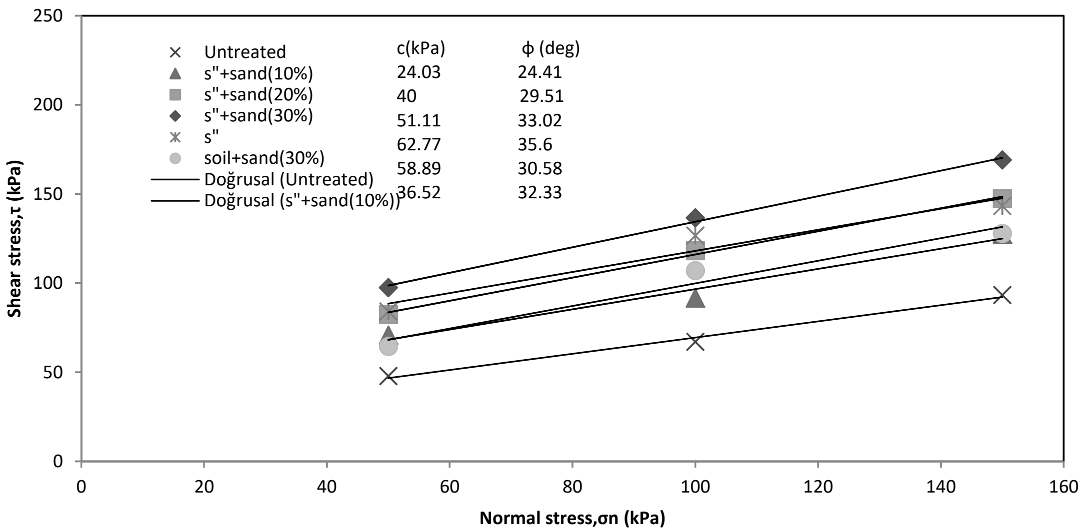

Fig. 4 Failure envelope of soil samples

IV. Conclusion

The study reveals that the soil has the following parameters:

1. Compaction characteristics of soil improve with the gradual slope barring sample with sand (30%) only.
2. A wide range of water contents are available for achievement of desired dry density.
3. The unconfined compressive strength of soil shows significant time dependent improvement.
4. In untreated soil, there is ductile failure. However, due to the presence of cement and sand in treated soil, brittle failure occurs.
5. The sample shows brittleness on addition of admixtures, and therefore it should be used with caution in the field.
6. Curing (7-days) of the soil samples increases the soil strength considerably.
7. Sample type (soil + cement (12%) + sand (30%)) shows maximum increase in unconfined compressive strength (qumax) of 1707 kPa from 78.97 kPa in untreated soil.
8. DST results reveal cohesion of the soil shows significant improvement as compared to the angle of internal friction.
9. CBR also shows significant improvement with its dependence on hydration time as well.
10. Cement treated samples are not affected by freezing/ thawing cycles which makes them useful in areas like Kashmir.

Scope of Future Work

- A less costly admixture which is locally available can be used to replace cementing admixture e.g. lime and make it more economically friendly.
- Settlement analysis of the sample can be checked.
- Compressibility characteristics of the soil are to be determined.

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