A STUDY OF PHYSICAL PROPERTIES AND STRENGTH PARAMETERS OF SAND AND BENTONITE MIX

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Abstract: *improving the geotechnical properties of clayey soil has always a critical problem for the civil engineering construction. A number of studies had been done by the researchers for improving the strength behaviour of soil. The technology used to enhance the strength behaviour of clayey soil is generally known as soil stabilization or modification. In present study, sand procured from the bank of River Gaula at Kathgodam, district. Nainital, (Uttarakhand) was mixed with different proportions of sodium bentonite. Physical properties of Gaula sand and bentonite were determined in the laboratory. Specific gravity, optimum moisture content (OMC), maximum dry density (MDD), porosity and void ratio were determined at different proportion of sand bentonite mix. Analysis of laboratory test conducted on the various proportions are discussed in the present paper.*

IndexTerms *- soil stabilization or modification.*

I. Introduction

The process of changing the properties of soil in such a way that the strength parameters of soil improve their strength and durability is known as term stabilization of soil. Researchers developed so many techniques to improve the stability of soil. These methods include compaction, consolidation, sand drains, mixing of chemicals/composite materials to the soil. Clayey soil is the most unpredictable soil because of its swelling and shrinkage properties. Clayey soil shows swelling and shrinkage property during increasing and decreasing of water content in the clayey soil. The areas where label of ground water table varies, swelling and shrinking of the clayey soil occurs periodically. Because of the periodically swelling and shrinking of clayey soil, the civil engineering structures constructed on it suffers from the considerable damage of the structure. In clayey soil, grater the percentage of clay has grater will be the optimum water content (OMC) and lower will be the maximum dry density (MDD). The present study was done on different percentage of gaula sand and bentonite mix. A number of test were conducted at various percentages bentonite mix with sand such as S100%B0%, S90%B10%, S80%B20%, S70%B30%, and S60%B40%. Specific gravity, atterberg limits, standard proctor test and strength parameters were studied.

2.0 Model Material Used

2.1 Gaula River Sand

The sample of Gaula River Sand was from the river Gaula near Kathgodam, Nainital, Uttarakhand. It was grey in colour and has been oven dried before conducting further laboratory tests.

Table-1: properties of sand.

Parameter	Value
Specific gravity (G)	2.68
Bulk Density (γ), g/cc	1.67
Plasticity Index	Non-Plastic
Maximum dry density (γ_d max), g/cc (Standard Proctor Test)	1.59
Optimum moisture content (OMC), %	4.70
Angle of internal friction (φ), degree	17.22
Cohesion (c), kPa	Negligible
Grain size distribution Sand size fraction (%) Silt size fraction (%)	 98.00 2.00
Soil type as per IS: 1498-1970	SP

2.2 Bentonite

Bentonite was used in the present study. Bentonite is an absorbent aluminium phyllosilicate, impure clay consisting mostly of montmorillonite. Bentonite usually forms from weathering of volcanic ash, most often in the presence of water. There are different types of Bentonite, each named after the respective dominant element, such as potassium (K), sodium (Na), calcium (Ca), and aluminium (Al).

Table-2: properties of bentonite.

Parameter	Value
Specific gravity (G)	1.63
Liquid Limit (%)	132.76
Plastic limit (%)	68.62
Plasticity Index (%)	64.14
Angle of internal friction (φ), degree	0
Cohesion (c), kPa	1.3
Soil type as per IS: 1498-1970	CH

2.3 Literature Review

A number of studies were conducted by the researchers such as **Gosavi et al. (2004) and Mittal and Shukla (2001)** investigated the strength behavior of locally available black cotton soil reinforced with randomly mixed geogrid woven fabric and fiberglass. **Kumar, et al. (2007)** have reinforced the black cotton soil. They investigated the unconfined compression of fly ash, lime and randomly oriented fibres on the geotechnical characteristics of expansive soil. **Naeini et al. (2009),** studies about the effect of plasticity index and reinforcement on the California Bearing Ratio (CBR) value of soft clay.

Chandra et al. (2008) have reinforced the three types of soil clay, silt and silty sand with polypropylene fibre of 0.3mm diameter. **Behzad et al. (2011)** Model study had been carried to stabilize peat soil using cement as binding agent and polypropylene fibers as additive. **Chegenizadeh et al. (2011)** conducted a series of laboratory CBR tests carried out to evaluate fibre effect on CBR values behaviour of composite sand. Clayey sand was selected as soil part of the composite and natural fibre was used as reinforcement. The fibre parameters differed from one test to another, as fibre length were changed from 20 mm to 50 mm and fibre content were varied from 1% and 3%.

Twinkle et al. (2011) studied regarding reinforcing effect of randomly distributed short polypropylene fibres on the compaction characteristics, penetration resistance and unconfined compressive strength of lime stabilised black cotton soil. **Naeini et al. (2011)** study was undertaken to investigate the effect of plasticity index and fiber content on the shear strength parameters (c and φ) of randomly distributed fiber-reinforced soil by performing direct shear tests. The results of this study showed that the peak shear stresses are significantly affected by fiber content, especially at high normal stresses.

KOTESWARA et al. (2012) study the effects on the properties of locally available Black cotton soil on the addition of polymer fibers with and without admixture modification. This study revealed that the fiber reinforcement improves the soil properties in terms of improved stress-strain patterns and progressive failure in place of quick post peak failure of plain samples.

Tiwari et al. (2013) studied taking two different types of fibres. Synthetic and natural fibres were used. For synthetic fibres, polypropylene fibbers manufactured from high-density polypropylene and polyethylene were taken. The natural fibres used are coir fibres. These natural fibbers are exceptions that they do not deteriorate and exhibit any loss of strength. **Mukherjee et al. (2015)** carried out to study the effect of polypropylene glass fiber on the geotechnical behaviour of various sand-bentonite mixtures amended with a layer of GCL. Fibers of 10 mm length in the proportion of 0.5% and 1% were added to the samples. The data shows that the swelling pressure and the swelling potential of the mixtures increased due to the addition of a layer of GCL to the mixtures.

3. Results and Discussion

3.1. Specific Gravity

Specific gravity of sand bentonite mix is determined by pycnometer method. The results below shows that gravity decreases on addition of bentonite in the sand.

Table-3: Specific gravity of sand bentonite mix

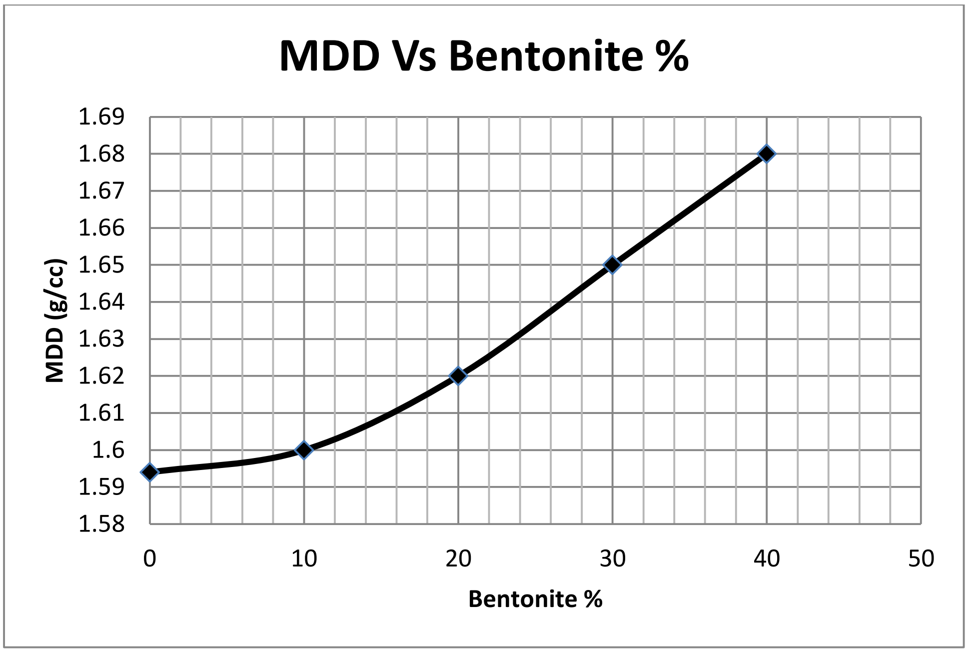
Description	Specific gravity (G)
Sand 100% Bentonite 0%	2.70
Sand 90% Bentonite 10%	2.64
Sand 80% Bentonite 20%	2.59
Sand 70% Bentonite 30%	2.52
Sand 60% Bentonite 40%	2.44

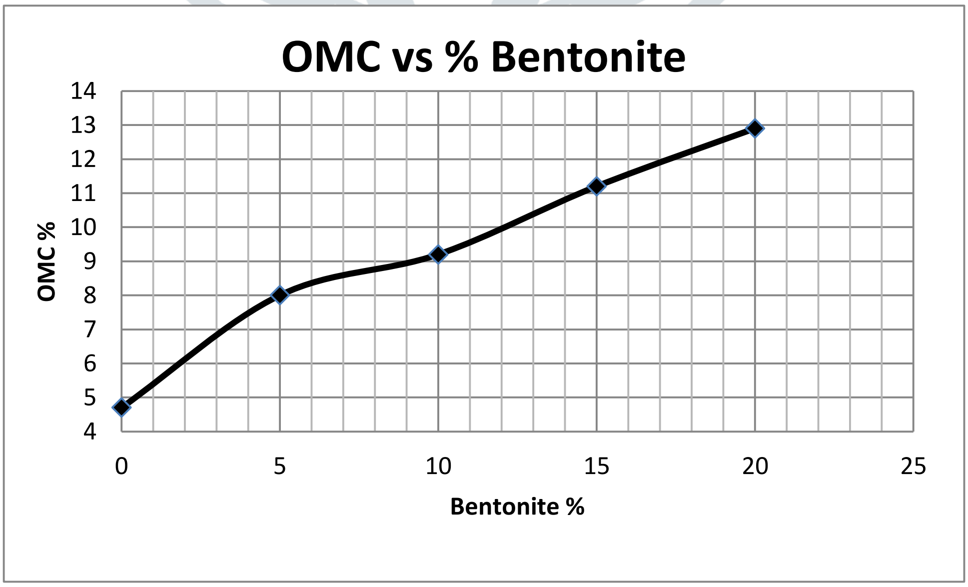
3.2. Standard Proctor Test

The compaction characteristics optimum moisture content and maximum dry density of the sand and Bentonite mixes were studied using Standard Proctor Test. Standard Proctor tests were conducted were conducted at various percentages bentonite mix with sand as per IS: 2720 (Part 7)-1980. The results are given below.

Table-4: OMC & MDD of sand bentonite mix

Description	MDD (g/cc)	OMC %
Sand 100% Bentonite 0%	1.59	4.70
Sand 90% Bentonite 10%	1.60	8.00
Sand 80% Bentonite 20%	1.62	9.20
Sand 70% Bentonite 30%	1.65	11.20
Sand 60% Bentonite 40%	1.68	12.90



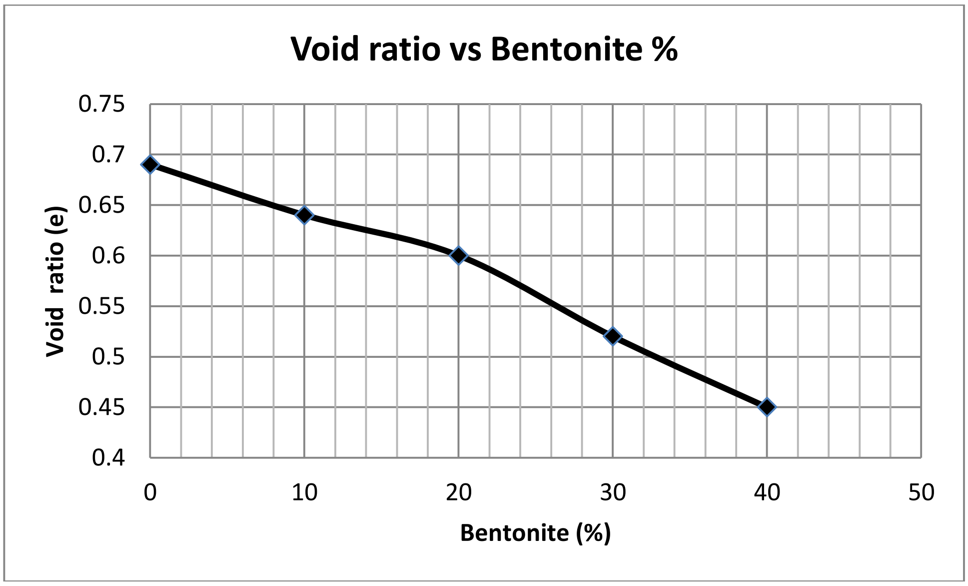


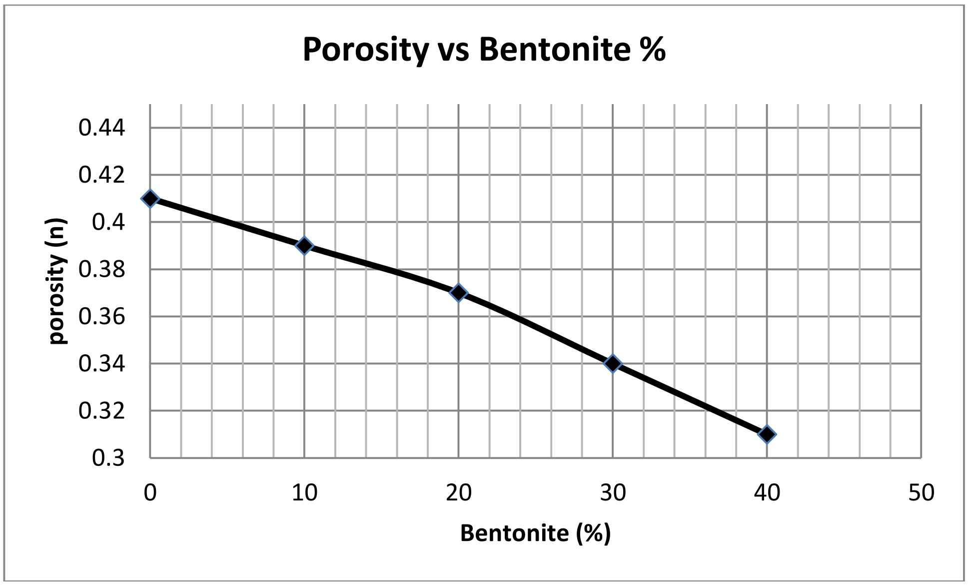
3.3. Void ratio and porosity

Void ratio and porosity were also determined for different mix proportions. Table 5 represents the variation of void ratio and porosity.

Table-5: OMC & MDD of sand bentonite mix

Description	Void ratio (e)	Porosity (n)
S100% B0%	0.69	0.41
S90% B10%	0.64	0.39
S80% B20%	0.60	0.37
S70% B30%	0.52	0.34
S60% B40%	0.45	0.31





3.4 Unconfined Compressive Strength

Unconfined Compressive Strength test were conducted at various percentages bentonite mix with sand. Samples were prepared at optimum moisture content for Unconfined Compressive Strength test. Following are the test results of the test.

Table-6: UCS & cohesion values

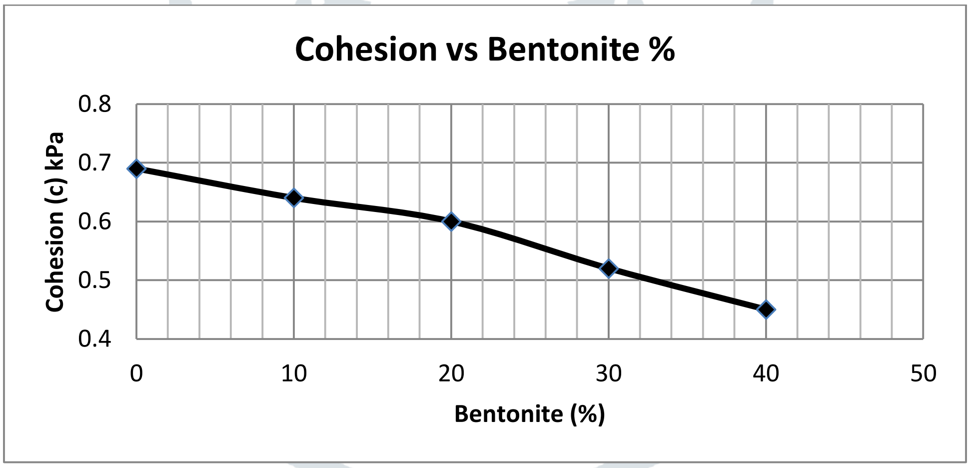
Bentonite (%)	qu (kPa)	cu(kPa)
10	51.27	25.64
20	124.58	62.29
30	155.18	77.59
40	204.39	102.20

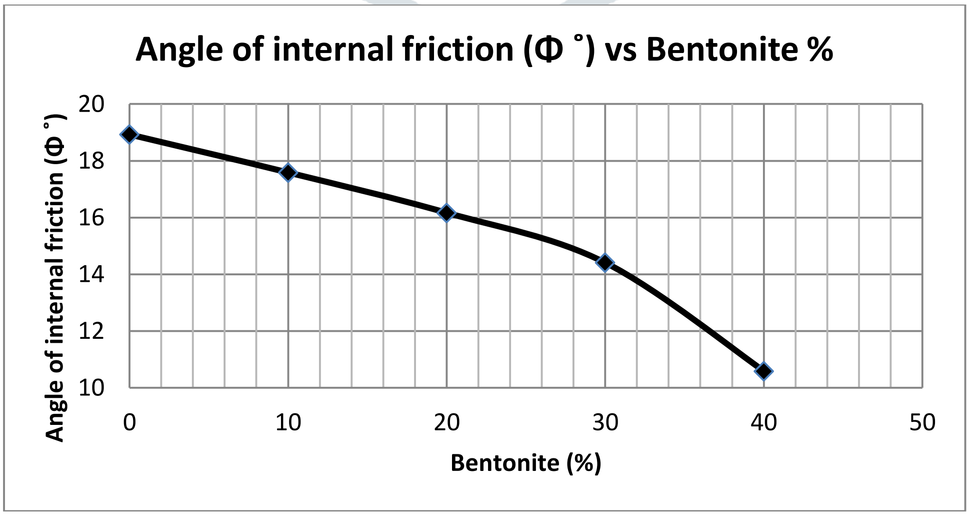
3.5 Direct shear test

A number of direct shear test were conducted to determine the shear strength parameters at various percentages bentonite mix with sand. The test procedure for the 'Direct shear test' as explained in Indian Standard Code (IS: 2720, Part XIII-1986) was referred for the study to determine the shear parameters. Tests were conducted at various percentages bentonite mix with sand. Samples were prepared at optimum moisture content for Direct Shear test. Following are the test results of the test

Table-7: OMC & MDD of sand bentonite mix

Description	Cohesion (c) kPa	Angle of internal friction (Φ ˚)
S100% B0%	0.84	18.93
S90% B10%	9.26	17.59
S80% B20%	16.63	16.17
S70% B30%	33.47	14.41
S60% B40%	45.48	10.59





4. Conclusion

A study has been conducted to investigate the effect of increasing the plasticity of soft soil on the strength parameters. For this study a number of tests were conducted on model material sand and bentonite. At varying percentage of bentonite the following tests results are obtained.

i. Specific gravity of sand bentonite mix decreases from 2.70 to 2.44 with increase in bentonite percentage in sand.

ii. Optimum moisture content (OMC) of sand bentonite mix increases from 4.70% to 12.90% with increase in bentonite percentage in sand.

iii. Maximum dry density (MDD) of sand bentonite mix increases from 1.59 g/cc to 1.68 g/cc with increase in bentonite percentage in sand.

iv. Void ratio of sand bentonite mix decreases from 0.69 to 0.45 with increase in bentonite percentage in sand.

v. Porosity of sand bentonite mix decreases from 0.41 to 0.31 with increase in bentonite percentage in sand.

vi. Unconfined compressive strength (UCS) increases from 51.27 kPa to 204.39 kPa with increase in bentonite percentage in sand.

vii. Cohesion value of sand bentonite mix increases from 0.84kPa to 45.48kPa with increase in bentonite percentage in sand.

viii. Angle of internal friction of sand bentonite mix decreases from 18.93˚ to 10.59˚ with increase in bentonite percentage in sand.

It is clearly shown that the rate of increase of cohesion value increases rapidly when percentage of bentonite increase beyond 20 %. Similarly rate of decrease of angle of internal friction value decreases rapidly when percentage of bentonite increase beyond 30 %.

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