A study on the effect of water content on strength and compressibility characteristics of marine clays

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Abstract *— Marine clays are predominant in the coastal regions and always a challenging task to study them. Marine clays are having stability issues and always needed to be address compressibility and strength characteristics. This paper presents a study on strength characteristics like unconfined compression strength and vane shear tests, Compression characteristics like consolidation, skemptons equation and change in void ratios at different water moulding conditions.*

Keywords — *Moulding Water content, OMC, MDD*

I. INTRODUCTION

Marine clays are generally found in the ocean bed. The properties of marine clay depend on its moisture conditions. The properties of saturated marine soil differ significantly from moist soil and dry soil. Marine clay is soft in consistency and is characterized by its high compressibility and low shear strength. They are fine grained soils with moderate to high clay fraction and are highly plastic in nature. Generally marine clay deposits vary from 10 to 30m in thickness along the coast line. The engineering properties like high compressibility, low shear strength and low permeability of marine clays pose serious challenges to geotechnical engineers in the various construction activities. Compression index is widely used in geotechnical engineering practice for calculation of settlement of foundations on clayey soils. Compression index is determined by conducting consolidation tests in laboratory on samples collected from field. The first well-known correlation of compression index based on liquid limit for remoulded clays was presented by Skempton (1944). Terzaghi and Peck (1967) presented a modified equation for normally consolidated clays. Soils having same liquid limit may vary in plastic and shrinkage limits, there by these soils exhibit different volume change behavior based on moisture contents.

II. METHODOLOGY

A. Material Used:

Marine clay is collected from Visakhapatnam port area in undisturbed and disturbed conditions.

B. Tests conducted:

1. The collected samples are dried and tested for various geotechnical characterization as per IS 2720.
2. Grain size distribution as per IS-2720 (Part 4):1985 (Reaffirmed- May 2015).
3. Consistency characteristics as per IS 2720 (part 5)-1985.
4. Compaction as per IS 2720 (part 6)- 1980
5. Consolidation as per IS 2720 (Part 15):1986.

III. RESULTS AND DISCUSSIONS

Undisturbed and disturbed samples of marine clay tested for above characterization are tested as per IS 2720 are shown in Table 1.

TABLE: 1 GEOTECHNICAL PROPERTIES OF MARINE CLAY

Grain size Analysis	
Gravel	0
Sand	2
Fines	98
Consistency	
wl	78
wp	32
Ip	46
IS soil classification	CH
Compaction	
OMC	27.5%
MDD	1.48 g/cc
Specific gravity	2.58
Compressibility	
e0	2.01
ef	1.48
cc	0.8

A. Strength characteristics of marine clay at various moulding water contents:

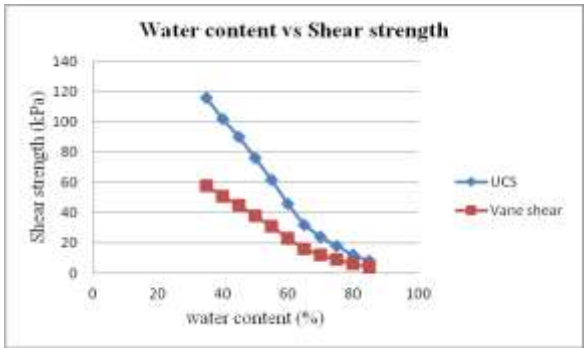
The behaviour of Marine clay varies with its consistency, especially at their moisture contents. In the present study remoulded samples are prepared at water contents such as 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80% and 85% that is beyond liquid limit and tested for shear strength using

unconfined compressive strength test and vane shear test. The test results are shown in table 2 and figure 1.

TABLE: 2 STRENGTH PROPERTIES OF MARINE CLAY

Water content (%)	UCS (kPa)	Shear strength (kPa)
35	116	58
40	102	51
45	90	45
50	76	38
55	62	31
60	46	23
65	32	16
70	24	12
75	18	9
80	12	6
85	8	4

FIGURE: 1 STRENGTH PROPERTIES OF MARINE CLAY



From the test results it is identified that strength values are decreasing with increasing water content in the Marine clay soil, nearing its OMC, high values are obtained in terms of unconfined compressive strength i.e., 116kpa and shear strength 58kPa respectively. At high water content i.e., above plastic limit unconfined compressive strength values are 76 to 90Kpa. Nearing to liquid limit the values are observed as 18 kPa, and above liquid limit the values are in between 8 to 12kPa.

The strength values of marine clay exhibited consistencies as stiff nearing to plastic limit medium stiff away from plastic limit soft consistency nearing to liquid limit and very soft consistency above liquid limit values.

B. Compressibility characteristics of marine clay at various moulding water contents:

To know the compressibility behaviour of marine clay samples are prepared that 35% to 85% and tested for void ratio compression index and percentage of compressibility values.

I.Initial void ratio: e0=wm x G

Where e_0 =initial void ratio

W_m = moulding water content

G = specific gravity of soil solids

II.Compressibility Index

C_c=0.007(wl-10) for remoulded soil

Where C_c= slope of void ratio - effective overburden pressure curve

III.Percentage Compressibility

$$\frac{\Delta H}{H} = \frac{\Delta e}{1+e0}$$

Where Δe= change in void ratio=(e0-ef)

$\frac{\Delta H}{H} x100$ is percentage of compressibility

The above calculated parameters are shown in table and in figure

TABLE: 3 COMPRESSIBILITY INDEX OF MARINE CLAY

Water content (%)	Skemptons	Consolidation
35	0.18	0.3
40	0.21	0.33
45	0.25	0.37
50	0.28	0.42
55	0.32	0.48
60	0.35	0.54
65	0.39	0.61
70	0.42	0.69
75	0.46	0.77
80	0.49	0.82
85	0.53	0.86

FIGURE: 2 COMPRESSIBILITY INDEX OF MARINE CLAY

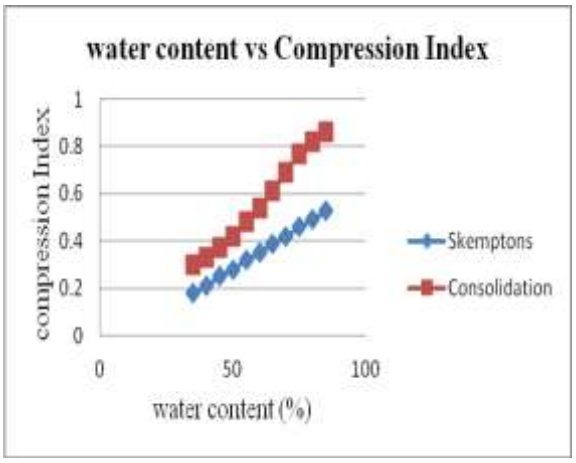
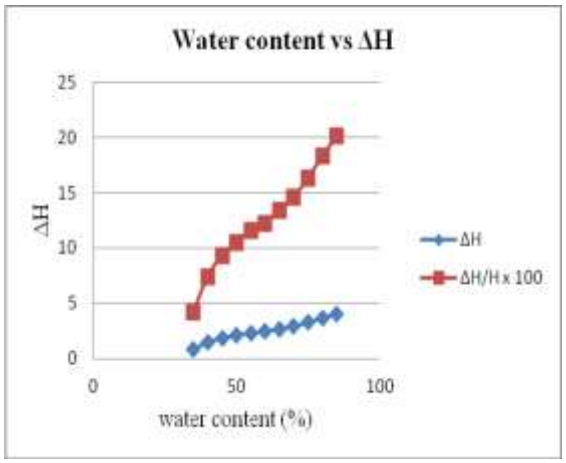


TABLE: 4 PERCENTAGE COMPRESSIBILITY OF MARINE CLAY

Water content (%)	**ΔH**	**ΔH/H x 100**
35	0.84	4.2
40	1.48	7.4
45	1.85	9.3
50	2.1	10.5
55	2.32	11.6
60	2.44	12.2
65	2.69	13.4
70	2.92	14.6
75	3.27	16.3
80	3.66	18.3
85	4.02	20.1

FIGURE: 3 PERCENTAGE COMPRESSIBILITY OF MARINE CLAY



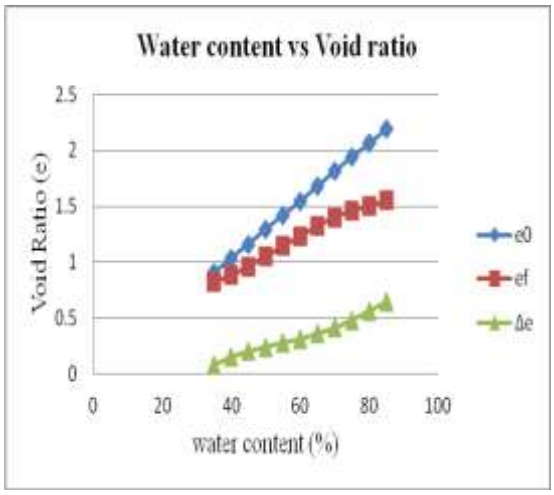
From the test results it is identified that compression index values are increasing with water content in Skempton and consolidation test results. High values are obtained at water contents nearing and above liquid limit values. Relatively higher values are reported from consolidation test data then skemptons equation. Nearing plastic limit range i.e., 30 to 40% it is 0.3 to 0.33 where as at liquid limit range of 70 - 80%, it is 0.7 to 0.82.

Similarly the percentage compressibility is in the range of 16 to 18.3 and their corresponding change in void ratio is 0.48 to 0.56 respectively.

TABLE: 5 CHANGE IN VOID RATIO OF MARINE CLAY

Water content (%)	e_0	e_f	Δe
35	0.9	0.82	0.08
40	1.03	0.88	0.15
45	1.16	0.96	0.2
50	1.29	1.05	0.24
55	1.42	1.14	0.28
60	1.54	1.23	0.31
65	1.68	1.32	0.36
70	1.81	1.4	0.41
75	1.94	1.46	0.48
80	2.06	1.5	0.56
85	2.19	1.55	0.64

FIGURE: 4 CHANGE IN VOID RATIO OF MARINE CLAY



IV. CONCLUSIONS

- Presence of high percentage of fines and its environment has a considerable influence on the strength and compressibility characteristics of marine clay.
- Moulding water content nearing to liquid limit the soil exhibits very soft consistency with high values of compression.

V. REFERENCES

[1] P.V.V.Satyanarayana, S. Hemanth Kumar, P. Praveen, B. V. Suresh Kumar *"A Study on Strength Characteristics of Expansive Soil-Flyash Mixes at Various Moulding Water Contents"*, International Journal of Recent Technology and

Engineering (IJRTE), ISSN: 2277-3878, Volume-2, Issue-5, November 2013, pp 145 149.

[2] P.V.V.Satayanarayana, Ganapati Naidu, P.S.Adiseshu, P.Padmanabha Reddy, "*A study on strength characteristics of flyash, lime and sodium silicate mixtures at their free pouring conditions*" International Journal of Computational Engineering Research (ijceronline.com) Volume-2 Issue-4; Pp: 1102-1108, August 2012.

[3] Yan Liang, Wei Li, Xinghua Wang "*Influence of Water Content on Mechanical Properties of Improved Clayey Soil Using Steel Slag*," in Springer, Geotech Geol Eng (2013) 31:83–91.

[4] IS-2720 (Part 4):1985 (Reaffirmed- May 2015).

[5] IS 2720: (Part 5): 1985 Methods of Test for Soils- Part 5: Determination of Liquid and Plastic limit.

[6] IS 2720: (Part 7): 1987 Methods of Test for Soils- Part 7: Determination of water Content and Dry Density Relation Using Light Compaction.

[7] IS 2720 (Part 15):1986. Methods of test for soils part 15 determination of consolidation properties.