An Experimental Study of Soil Stabilisation Using Sodium Hydroxide Additive

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Abstract **:-The objective of this paper is to investigate the effect of adding different percentage of sodium hydroxide on the engineering properties of nearby clayey soil. In the present study, the amount of sodium hydroxide is taken as 2%, 4%, 6%, 8%, 10%, by weight of the soil as soil stabilizer for the investigation purposes. From the present study it is found that 6% of sodium hydroxide is best or we can say that it is optimum for reducing the optimum moisture content of the soil as the value of OMC reduces from 15.4% to 9.87%. After further addition of sodium hydroxide the OMC starts increasing which is not good for the clayey soil. Also from the investigation it is found that the maximum dry density (MDD) of the natural soil increases upto 5% to 6% of sodium hydroxide and after that MDD starts decreasing. The value of maximum dry density (MDD) increases from 1.72g/cc to 1.91g/cc. After addition of sodium hydroxide, the value of UCS increases from 3.47kg/cm^2 to 4.12 kg/cm^2 upto 6% addition of sodium hydroxide.**

Keywords **— Soil Stabilization, Chemical additives, Sodium Hydroxide, Optimum moisture content, Maximum dry density, unconfined compressive strength.**

I. INTRODUCTION

Soil stabilisation is the alteration of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. Clayey soil is widely present in many parts of India, covers about 40 percent of the total area of the country .Seasonal climatic changes can cause clay soil to swell and shrink posing difficulties in engineering applications. These volume changes alter the structure of these soils leading to changes in soil behaviour there are three purposes for soil stabilisation. These include increasing strength of an existing soil to enhance its load-bearing capacity, permeability improvement and enhancement of soil resistance to the process of weathering, and traffic usage among others **[10].** The method of soil stabilization is determined by the amount of stabilising required and the conditions encountered on the project. An accurate soil description and classification is essential to the selection of the correct materials and procedure**s [12], [13],** this study aims at stabilizing the soil chemically using NaOH as a stabilizing agent. Sodium Hydroxide is an odourless, white flake, non-combustible solution, it does not burn but it is highly reactive material. NaOH breaks into (Na+ and OH-) ions, which interacts with mineral of soils to exhibit change in its properties. Dharmendrasahu has investigated the effects of NaoH on mixing with the black cotton soil as a stabilizing material. He documented that ions Na+ and OH- interact with silica and alumina present in soil to chemically change its properties**.** Gogo suggested that the stabilization of soil from Ghana for building and construction purposes by mixing and curing the soil with various additives **[9].** These additives have shown the best resistance to failure in dry state however NaOH has shown the best resistance to failure in wet state. It was als**o** found that, the decrease in liquid limit with increase in the concentration of NaOH was due to the predominant influence of increase in electrolyte concentration **[14**]. Chemical stabilization can aid in dust control on roads and highways, particularly unpaved roads, in water erosion control, and in fixation and leaching control of waste and recycled materials**[11**] .A chemical stabilization method is the fundamental of this review since it produces better quality soil with high strength and durability than mechanical and physical techniques and therefore, throughout the rest of this report, the term soil stabilization will mean chemical stabilisation.Under this category, soil stabilization depends mainly on chemical reactions between chemical additives and soil particles which then produce a strong network that bind the soil grains to achieve the desired effect. In chemical stabilization soil is stabilized by adding different chemicals. The main advantage of chemical stabilization is that setting time and curing time can be controlled.

A. Advantages of Chemical Stabilization

1) In this stabilization method, setting time and curing time can be controlled.
2) It gives more strength to the soils.
3) The compacted density of the soil is increased.
4) Chemical stabilization increases the permeability of the soil

Sodium hydroxide in a solution is a white, odourless, non-volatile solution. It doesn't burn but highly reactive. It reacts violently with water and numerous commonly encountered materials, generating enough heat to ignite nearby combustible materials. Its principal advantages are that it can easily react with water which results into a powerful compaction aid giving a higher density for the same compaction effort **[13**].

This paper describes an investigation into the effect of adding sodium hydroxide (NaOH) on the engineering properties of clayey soil taken from the B.I.T., Sindri, and Jharkhand campus.

II. MATERIALS USED

For stabilisation of soil using sodium hydroxide (NaOH), materials used are described in table 1.

TABLE: 1 MATERIALS USED

S.N.	Name of materials	Source of material/supplier
1.	Soil	B.I.T Sindri campus
3.	Sodium hydroxide (NaOH)	E-Merck Worli Mumbai
5.	Sodium carbonate	Pallav Chemicals &Solvents Pvt. Ltd. Tarapur, Boisar
6.	Sodium hexametaphosphate	E-Merck Worli Mumbai

A. SOIL

The soil sample used in this study was collected from B.I.T. Sindri campus from a depth of 1m to 1.2 m below the ground surface by excavation; the soil was dried and pulverized to perform the various experiment studies.

Table 2: General properties of raw soil

PROPERTIES OF SOIL	EXPERIMENTAL VALUE
OMC (%)	15.42
MDD(gm/cc)	1.74
SPECIFIC GRAVITY	2.40
CBR (SOAKED)	4.25
CBR(UNSOAKED)	9.00
LIQUID LIMIT (%)	38.15
PLASTIC LIMIT (%)	20.56
PLASTICITY INDEX (%)	17.59
UCS (kg/cm^2)	3.47
PERCENTAGE FINER (CLAY+SILT) (%)	63.5
CLASSIFICATION OF SOIL	CI

From the standard proctor test, the compaction curve was obtained as shown in figure below:

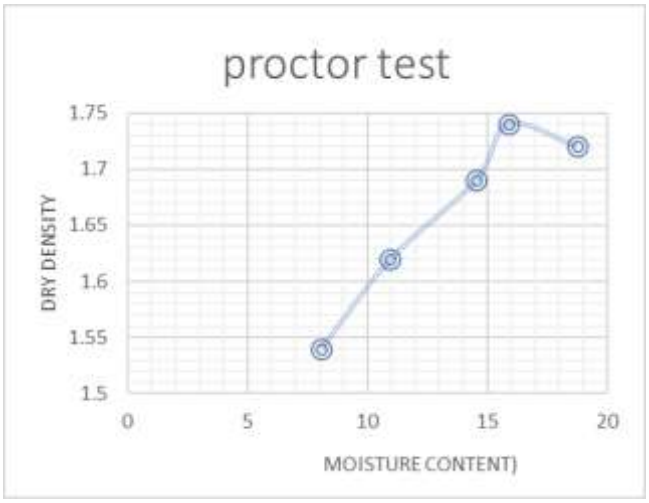


Figure 1: standard proctor test

From above curve:-

Maximum dry density=1.74g/cc

Optimum moisture content=15.42%

From wet sieve analysis and hydrometer test, Grain size distribution curve is plotted.

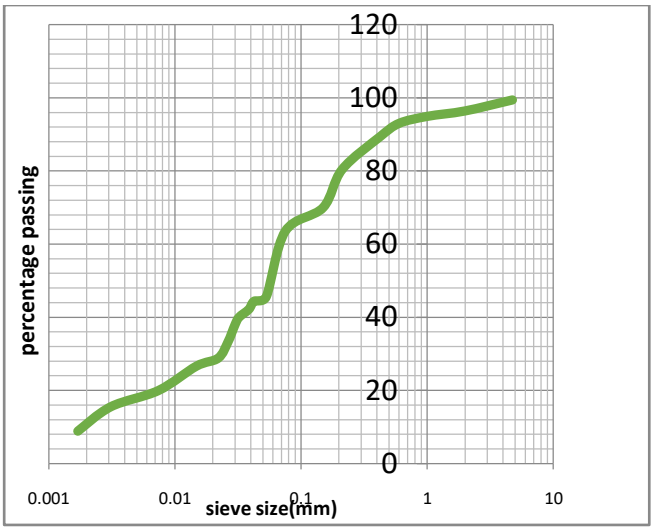


Figure: 2 Grain size distribution curve of natural soil

From above graph and calculations, it is found:

Percentage of clay = 15.24%

Thus, the classification of soil is **CI (Clay with intermediate compressibility)**

B. Sodium hydroxide (NaOH)

Table 3: Properties of sodium hydroxide

1.Chemical Formula	NaOH
2.Molar Mass	39.9971g/mol

3.Melting Point	318℃
4.Density in natural state	2.13g/cc
5.Acidity	13
6.Type of bond	Ionic
7.Sodium content	57.48%
8.Oxygen content	40.00
9.Hydrogen content	2.52

III. SAMPLE PREPARATION

Following steps were carried out to prepare NaOH solution:

1. The concentrations of sodium hydroxide have been prepared based on the percentage by weight of the soil mass.
2. Different percentage of sodium hydroxide i.e; 2%, 4%, 6%, 8%, 10% is taken by weight of soil.
3. After that desired percentage of sodium hydroxide is added with water to make the NaOH solution.

For experimental study different soil samples have been prepared with different proportions of sodium hydroxide, which have been given in the table below:

Table 4: Description of samples

Sl.No.	Nomenclature	Description of additives added with the soil	
		Soil (%)	NaOH(% by wt. of soil)
1.	N_1	100	0
2.	N_2	98	2
3.	N_3	96	4
4.	N_4	94	6
5.	N_5	92	8
6.	N_6	90	10

IV. EXPERIMENTAL INVESTIGATION

A. Proctor Compaction Test

Standard proctor test**:-**Used for the determination of optimum moisture content and maximum dry density of the local soil taken from the BIT, Sindri campus.

EQUIPMENTS & APPARATUS REQUIRED

Cylindrical mould & accessories [volume = 1000cm^3], rammer (2.6 kg), sieves (20mm), mixing tray, trowel, graduated cylinder, metal container.

PROCEDURE:-

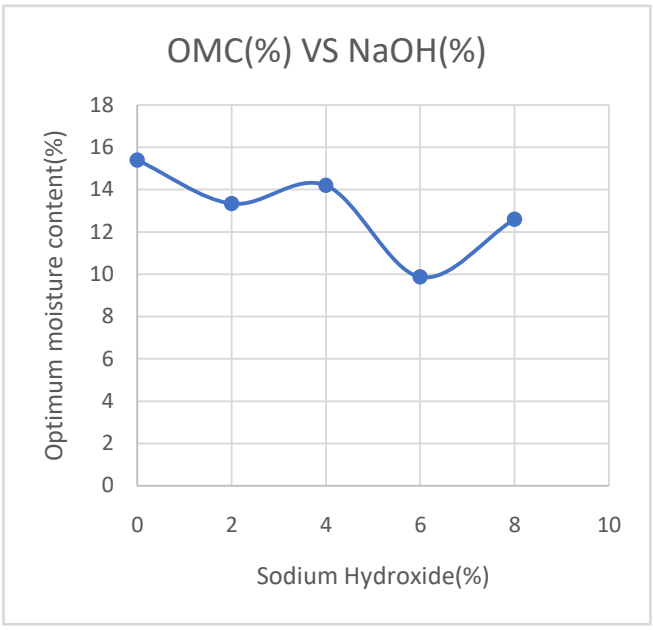
1. Air dried soil passing through the I.S. sieve 20mm size is taken.
2. It is then thoroughly mixed with small quantity of water in a pan.
3. Weigh the empty mould and find its volume(V).
4. Fil the mould in 3 layers , compacting each layer by 25 blows with a hammer.
5. then the soil is trimmed to the top of mould.
6. Weigh the mould with the soil.
7. Take a sample of the soil and determine its water content(w) using oven drying method.
8. Repeat the process for 5 ranges of water content or even more if necessary.

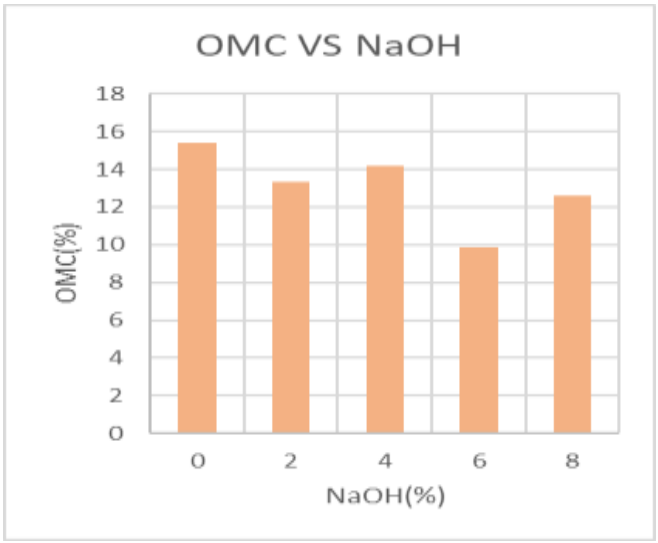
Results and Discussion

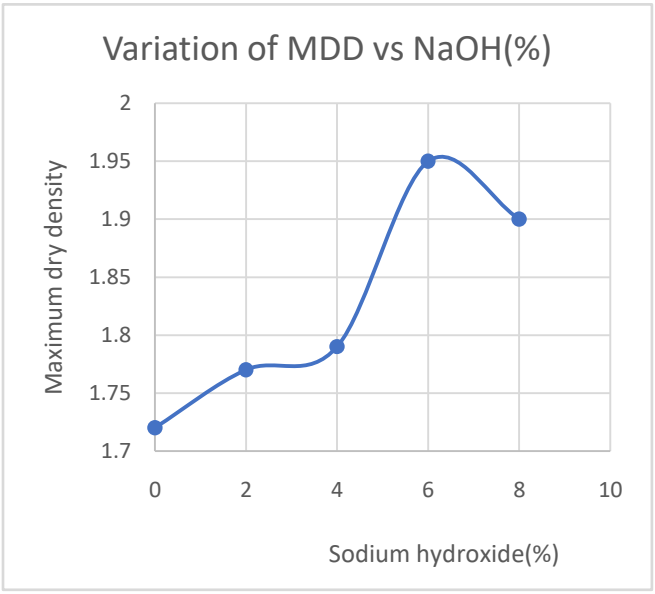
OMC AND MDD: - To know the compaction characteristics (OMC & MDD) test have been performed on different mix proportion of soil with sodium hydroxide (NaoH) additives.

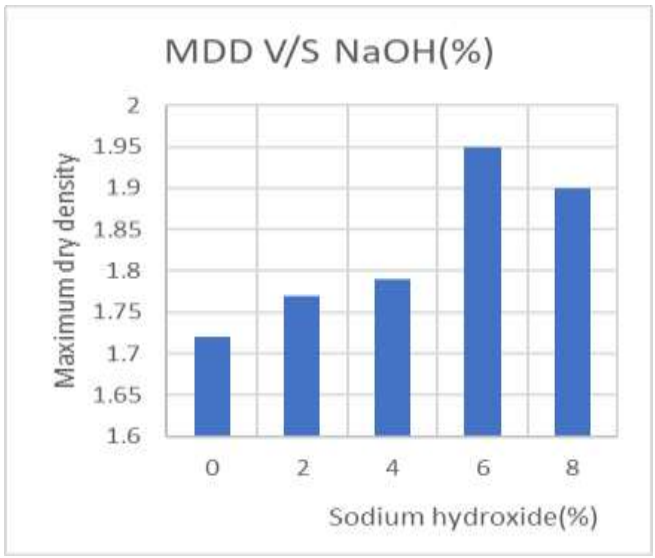
Table 5: Values of OMC and MDD test results

SL.NO.	SAMPLE TYPE	OMC (%)	MDD(g/cc)
1.	N_1	15.4	1.72
2.	N_2	13.34	1.77
3.	N_3	14.20	1.79
4.	N_4	9.87	1.95
5.	N_5	12.60	1.90







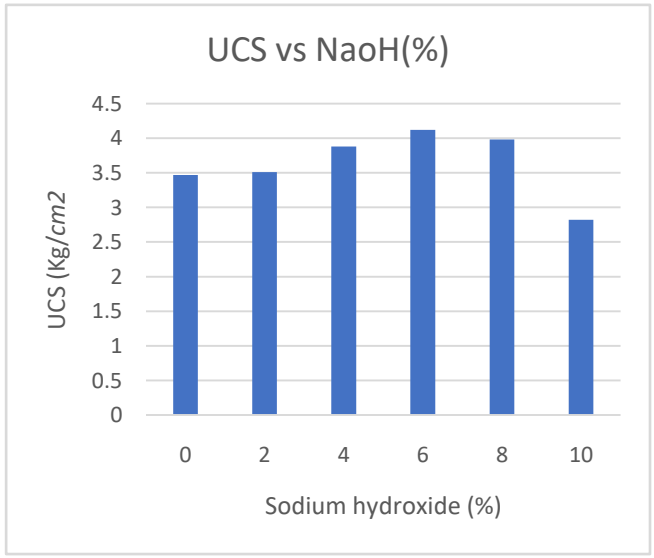


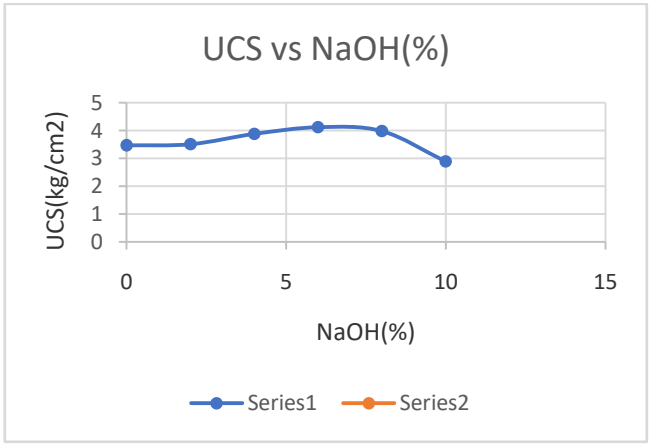
B. Unconfined Compressive Strength (UCS) Test

The main objective of this test is to determine the unconfined compressive strength of a cohesive soil. It is defined as the load per unit area at which an unconfined cylindrical specimen of soil will fail in the axial compression test. Since there is no confined pressure, so it is called unconfined compression test.

Table 6:- Values of UCS test results

SL.NO.	SAMPLE TYPE	UCS (Kg/cm^2)
1.	N_1	3.47
2.	N_2	3.51
3.	N_3	3.88
4.	N_4	4.12
5.	N_5	3.98
6.	N_6	2.82





V. CONCLUSION

On the basis of results discuss, following conclusion had been drawn:-

1. From the above experimental data it is found that the minimum optimum moisture content of the soil is at the addition of 6% of sodium hydroxide and after further addition of sodium hydroxide moisture content start increasing.Therefore it is recommended that for minimum moisture content we should adopt 5% to 6% of NaOH.
2. It is also found that the maximum dry density of the soil increases upto 6% of NaOH and after further addition of NaOH it starts decreasing. Therefore for construction purpose we should adopt 5% to 6% of NaOH as optimum content.
3. After addition of sodium hydroxide, the value of UCS increases from 3.47kg/cm^2 to 4.12 kg/cm^2 upto 6% addition of sodium hydroxide, beyond that the value of UCS decreases as shown above. So it is recommended to use 5% to 6% of sodium hydroxide as stabilizer.

APPENDIX

Following abbreviations are used:-

1. IS – Indian Standard

2. MDD- Maximum dry density

3. NaOH- Sodium Hydroxide

4. OMC -Optimum moisture content

5. UCS- Unconfined compressive strength

6. CBR- California bearing ratio

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