

Stabilisation of Soil Using Sodium Hydroxide Additive

¹Krishna Keshav, M. Tech Student, Civil Engineering Department, BIT Sindri, Dhanbad, India

²M.K. Mishra, Assistant Professor, Department of Chemistry, BIT Sindri, Dhanbad, India

³J.P. Singh, Associate Professor, Civil Engineering Department, BIT Sindri, Dhanbad, India

¹mausam.krishna@gmail.com, ²mkmishrabit@gmail.com, ³profjpsbit@gmail.com

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 optimum for reducing the optimum moisture content (OMC) 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/cm² to 4.12 kg/cm² 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 modification of one or more soil properties, by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. About 40 percent of the total area of the country is covered by clayey soil. Periodic climatic change can cause clay soil to swell and shrink posing difficulties in engineering applications. These volume changes modify the structure of the 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 enrichment of soil resistance to the process of weathering, and traffic usage among others [1]. 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 procedures [2], [3]. 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. Stabilization of soil from Ghana was done for building and construction purposes by mixing and curing the soil with various additives [4], [5]. 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 also 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 [6]. 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[7]. A chemical stabilization method is the fundamental of this review since it produces better quality of 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. Advantage 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 generate enough heat to ignite nearby combustible materials. Its principal advantages is that it can easily react with water which results into a powerful compaction aid giving a higher density for the same compaction effort [3],[8],[9].

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,Jharkhand campus.

II. MATERIALS USED

For stabilisation of soil using sodium hydroxide(NaOH), following materials were used as 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 digging, then the soil was dried and ground to perform the various experimental work.

Table 2 illustrate the general properties of raw soil as obtained from the experimental work.

Table 2: General properties of raw soil [10],[11],[12],[13],[14],[15],

| 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 |

GRAIN SIZE DISTRIBUTION: -

From wet sieve analysis and hydrometer test, Grain size distribution curve is plotted as shown in figure 2.

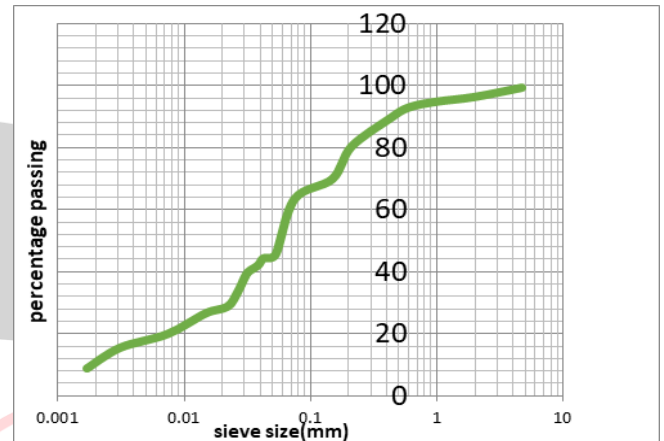


Figure:1 Grain size distribution curve of natural soil

From above graph and calculations, it is found that 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 °C |
| 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 has 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 amounts of sodium hydroxide, which have been specified 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 = 1000cm³], 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. Empty mould was weighed and its volume(V) had been found.
4. Mould was filled in 3 layers compacting each layer by 25 blows with a hammer.
5. Then the soil was trimmed to the top of mould.
6. Mould with the soil was weighed.
7. Sample of the soil was taken and its water content (w) was determined using oven drying method.
8. The process was repeated for 5 ranges of water content.

From the standard proctor test, the compaction curve for natural soil was obtained as shown in figure 2.

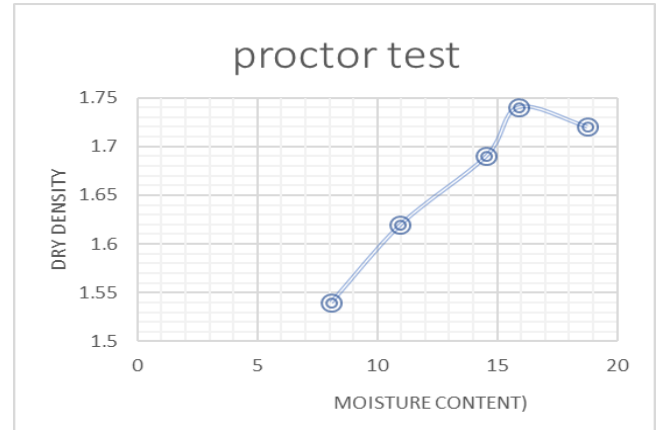


Figure 2: standard proctor test

From above curve: -

Maximum dry density=1.74g/cc

Optimum moisture content=15.42%

V. 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 [15]

| 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 |

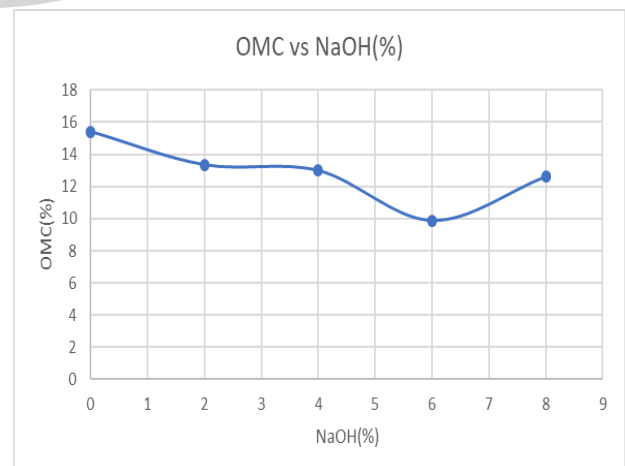


Figure:3 Variation of OMC with NaOH

Above graph shows that, with the variation of sodium hydroxide percentage, optimum moisture content varies and is minimum at 6% of NaOH.

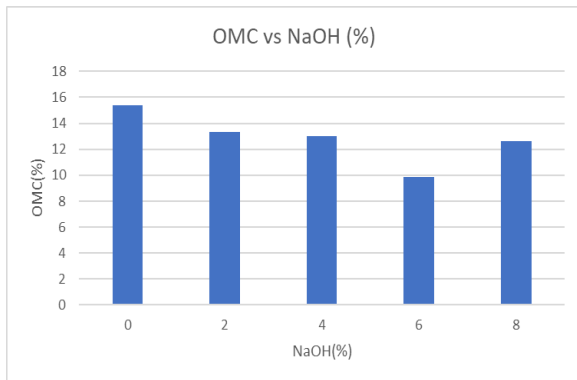


Figure:4 Variation of OMC with NaOH

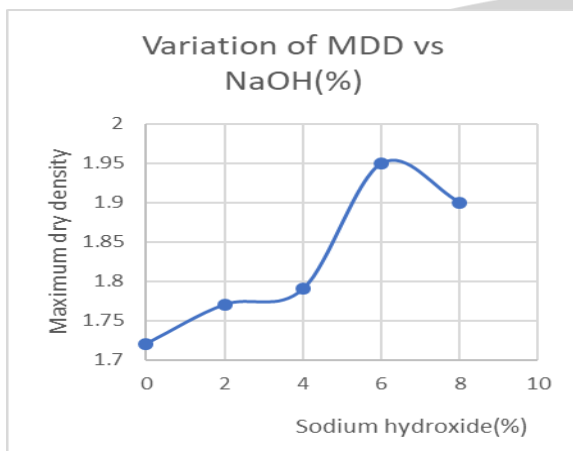


Figure:5 Variation of MDD with NaOH

Above graph shows that, with the variation of sodium hydroxide percentage, maximum dry density varies and is maximum at 6% of NaOH.

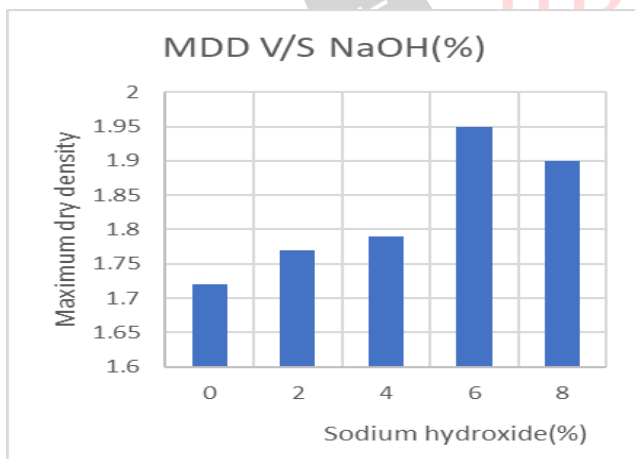


Figure:6 Variation of MDD with NaOH

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 [10]

| 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 |

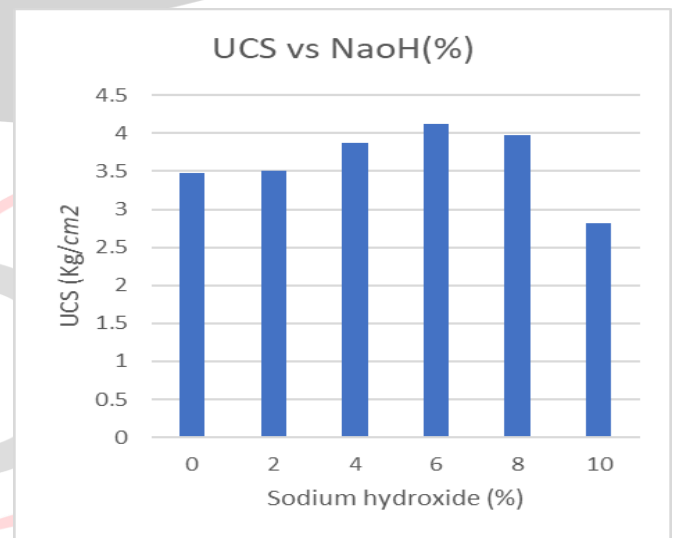


Figure:7 Variation of UCS with NaOH

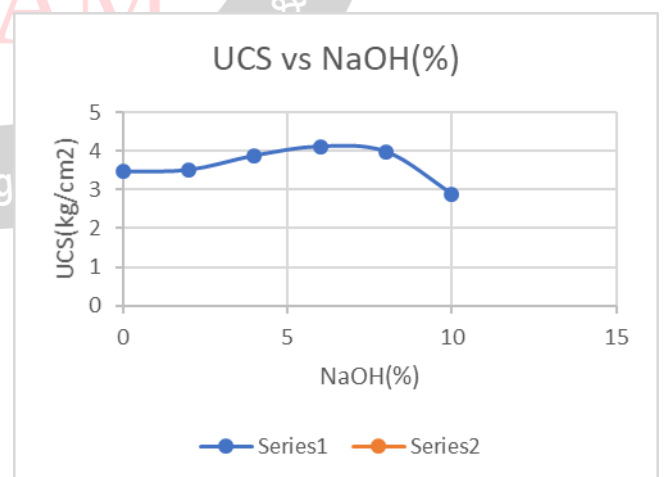


Figure:8 Variation of UCS with NaOH

Above graph shows that, with the variation of sodium hydroxide percentage, unconfined compressive strength varies and maximum at 6% of NaOH.

VI. CONCLUSION

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

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 to use 5% to 6% of NaOH for minimum moisture content. 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 5% to 6% of NaOH as optimum content can be used. After addition of sodium hydroxide, the value of UCS increases from 3.47kg/cm² to 4.12 kg/cm² upto 6% addition of sodium hydroxide, beyond that the value of UCS decreases. So, it is recommended to use 5% to 6% of sodium hydroxide as stabilizer.

VII. APPENDIX

Following abbreviations are used

1. MDD- Maximum dry density
2. NaOH- Sodium Hydroxide
3. OMC -Optimum moisture content
4. UCS- Unconfined compressive strength
5. CBR- California bearing ratio

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