

# Stabilisation of Soil by using Tiles waste with Sodium Hydroxide as Binder

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**ABSTRACT:** This paper deals with enhancing the engineering properties of weak soil by treating it with tile waste with sodium hydroxide as binder. Weak soil generally swell significantly when come in contact with moisture and shrink when the moisture squeezes out, and this type of soil will have low bearing capacity. Therefore it is necessary to stabilize weak soil, thus improving the load bearing capacity of a sub grade to support pavement and foundation. The weak soil is collected locally and mixed with varying percentage of tile waste with sodium hydroxide as binder. On the basis of different composition of tile waste and sodium hydroxide as binder, liquid limit test, plastic limit test, falling head permeability test, standard proctor test, California bearing ratio test(CBR), direct shear test were conducted on soil sample and checked the improvement in engineering properties of soil.

**KEYWORDS:** CBR, sodium hydroxide, Tiles waste ,weak soil.

## I. INTRODUCTION

Clayey soils are of particular interest in agricultural, geotechnical engineering and environmental application. Clayey soils commonly develop desiccation (shrinkage) cracking which has a significant influence on the transport of moisture and solutes. Seasonal climatic changes can also 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. A primary feature of clay soil is that they undergo changes in bulk soil volume during wetting and drying. The amount of volume change is, in fact a reflection of the degree of structural change that is taking place. Desiccation cracks can have a paramount influence on the structure development of clay soils.

Clayey soil is widely many parts of India covers about 40 percent of the total area of the country. Most of the structure constructed on the clayey soil fails due to alternate shrink swell behaviour of the soil. Therefore it is necessary to stabilize this type of soil by using locally available waste material. The engineering properties of clay soil are improved by the utilization of tiles waste with sodium hydroxide as binder. A large amount of tiles waste is produced from manufacturing units as well as from construction site. The problem of the disposal of tiles waste can be solving by utilizing in economic way for soil stabilization.

*Ajay Upadhyay* (July 2016) has evaluated the use of ceramic waste in soil stabilization improves the geotechnical properties of soil. He says that addition of ceramic waste in soil liquid limit, plastic limit and plasticity index of clayey soil decreases. *Akshaya kumar sabat*( August 2016) has reported that the usage of ceramic dust up to 30% can be used in strengthening the subgrade. From the economic analysis, the utilization of ceramic dust for soil stabilization saves the cost. *Dharmendrasahu* has investigated the effects of NaOH on mixing with the black cotton soil as a stabilizing material. He documented that ions Na<sup>+</sup> and OH<sup>-</sup> interact with silica and alumina present in soil to chemically change its properties. *Dhiaadin Bahaadin Noory Zangana* has found that CBR value for the investigated

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soil treated with sodium hydroxide increased to a maximum value at certain sodium hydroxide concentration and then decreased with increase in the sodium hydroxide concentration.

## II. OBJECTIVE

- To evaluate the engineering properties of clayey soil with respect to different mix proportions of tiles waste with sodium hydroxide.
- To study the change in CBR value when the clayey soil is mixed with different percentage of tiles waste and sodium hydroxide.
- To study the suitability of soil for foundation by studying the variation in shear strength and bearing capacity.

## III. MATERIALS USED

### A. Weak soil

The clayey soil used for experiment was collected from Melapulam village at about 30km away from Vellore district located in Tamil Nadu. The properties of clayey soil are detailed below

S.No	Properties of soil	Values
1.	Natural moisture content	5.55%
2.	Specific gravity	2.56
3.	Liquid limit	51%
4.	Plastic limit	26.7%
5.	Plasticity index	22.63(CI Group)
6.	Standard proctor test	
	Maximum dry density	1.74
	Optimum moisture content	20%
7.	Shear strength	0.14
8.	CBR value(@ 2.5mm penetration)	1.93

### B. Tiles waste

A ceramic tile is an inorganic, non metallic, solid material. The earliest ceramics made by humans were pottery objects made from clay either by itself or mixed with other materials like silica. Later ceramics were glazed and fired to create smooth, coloured surfaces, decreasing porosity. The raw materials to form tile consists of clay mineral mined from earth crust, natural mineral such as feldspar.

A lot of tile waste is produced during formation, transportation and placing of ceramic tiles. The disposal of tile waste is a major problem so it is used effectively used for soil stabilization. tile waste is made into powder form by hand ramming and tile waste powder passing 90 micron sieve is replaced with soil.

### C. Sodium hydroxide

Sodium hydroxide is a white crystalline solid and is highly reactive, it is odourless and non-volatile solution. It can generate enough heat to ignite combustible materials nearby and also react violently with water. The main advantage of sodium hydroxide is it can be a great compaction aids by giving higher density for the same compactive effort when react with water.

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## V.METHODOLOGY

The soil used for the experimental work is collected from selected area. The soil is oven dried and then it is sieved through respective sieve sizes(425 $\mu$ ,90 $\mu$ ,4.75mm) for the corresponding test. The tile waste were broken into powder form by hand ramming. The tile waste and sodium hydroxide is mixed with corresponding soil sample at different proportions. The soil is mixed with the tile waste and NaOH to make a homogenous mix. This mix is then transferred to the container and it is dries in oven for 24hours at 80°C and then the sample is used for the experimental works.

## VI.EXPERIMENTAL WORK

### 6.1. INDEX PROPERTIES

Liquid limit and plastic limit of the clayey soil was obtained by treating it with different percentage of tiles waste powder and sodium hydroxide as binding agent. The test were conducted on the soil sample according to IS 2720(part5)1985.

Table.1 Determination of plasticity index of sample on replacement of tiles waste and NaOH

% of tile waste	% of NaOH	Liquid limit	Plastic limit	Plasticity index (IS1498 1970)	Group (IS1498 1970)
5%	2.5%	48.5	26	20.8	CI
10%	5%	43	24.76	16.79	CI
15%	7.5%	37	23.15	12.41	MI
20%	10%	34	22.01	10.22	CL
25%	12.5%	30	21.87	7.3	CL
30%	15%	25	19.61	3.65	ML
35%	17.5%	22	18.98	1.46	ML
40%	20%	28	22.58	5.84	CL

The table 1 shows the value of liquid limit and plastic limit with varying percentage of tiles waste and sodium hydroxide. From the table, it can be evaluated with the addition of tiles waste upto 35% and NaOH upto 17.5% the liquid and plastic limit decreases beyond this limit the value increases. As per IS 1498-1970 the soil group changes from CI group to ML group.

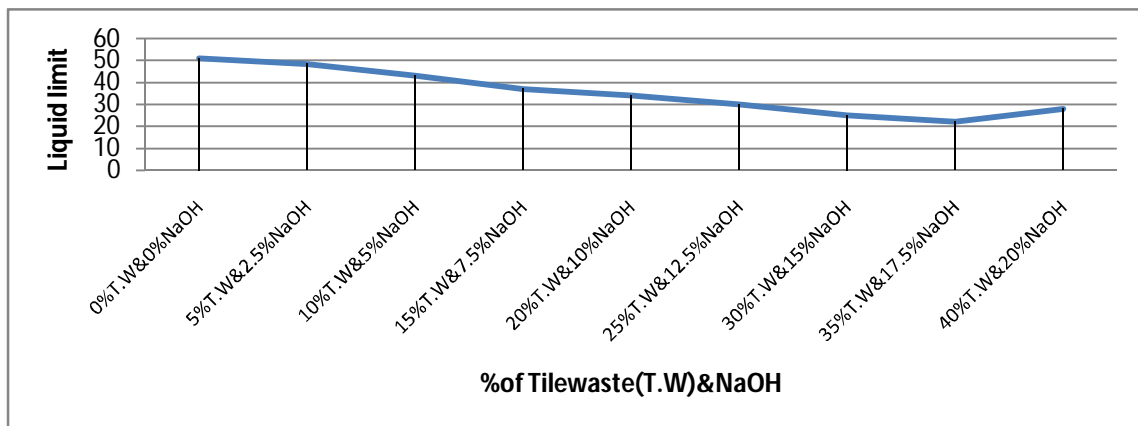


Fig.1.Liquid limit result with varying percentage of tiles waste & NaOH

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The obtained result of liquid limit treated with different percentage of tiles waste and sodium hydroxide as shown fig.1. From the fig it can be noted that with the increase in percentage of tiles waste and NaOH the liquid limit of soil decreases from 51% to 22% and slightly increases on addition of 40% tiles waste and 20% of NaOH.

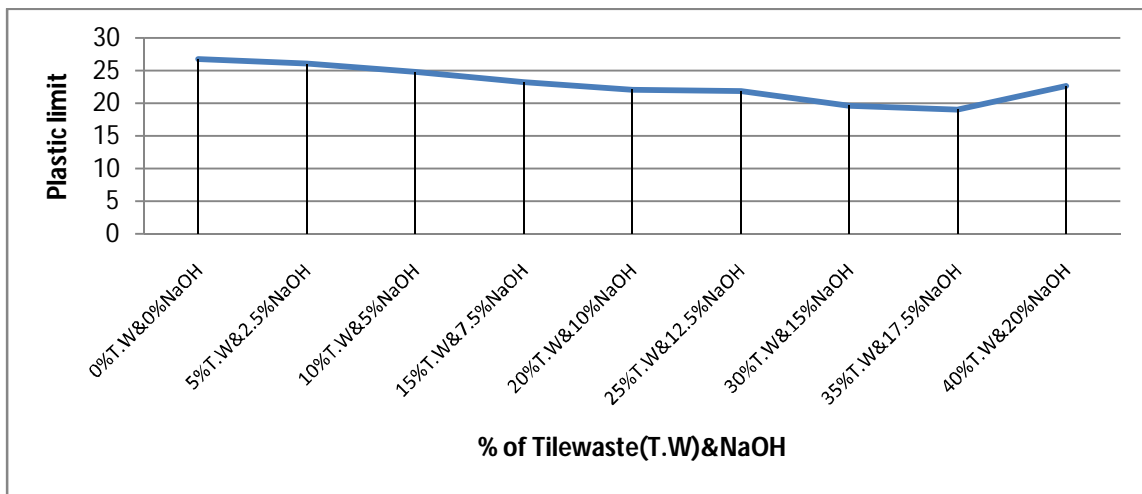


Fig.2 Plastic limit result with varying % of tiles waste & NaOH

The obtained result of plastic limit treated with different percentage of tile waste and NaOH as shown in fig.2. From the fig.2 it can be seen that with increase in percentage of tile waste and NaOH the plastic limit of soil decreases from 26.72 to 18.98 and increases in addition of 40% of tile waste and 20% of NaOH. From the obtained result it has been found that on addition of tile waste and NaOH, the soil changes from CI group to ML group as per IS 1498-1970.

## 6.2. STANDARD PROCTOR TEST

This test is used to determine optimum moisture content and the corresponding dry density of the soil sample passing through 4.75mm sieve and mixed with different percentage of tile waste and NaOH as binding agent. About 2.5kg of soil sample is taken and then compacted in three equal layers by giving 25 blows using rammer weighing 2.6kg dropping from a height of 31cm. The test was conducted on soil sample according to IS 2720 part 7-1980.

Table.2 Determination of dry density of sample replaced with varying percentage of tiles waste and NaOH

% of Tilewaste	% of NaOH	MDD (gm/cc)	OMC
5%	2.5%	1.784	20%
10%	5%	1.874	16%
15%	7.5%	1.93	16%
20%	10%	1.99	12%
25%	12.5%	2.042	12%
30%	15%	2.054	12%
35%	17.5%	2.108	8%
40%	20%	1.91	12%

The table 2 shows the value of maximum dry density and optimum moisture content with varying percentage of tiles waste and NaOH. From the table it can be seen that the maximum dry density and gradually increases with the addition of tiles waste up to 35% and NaOH up to 17.5% and decreases beyond this limit.

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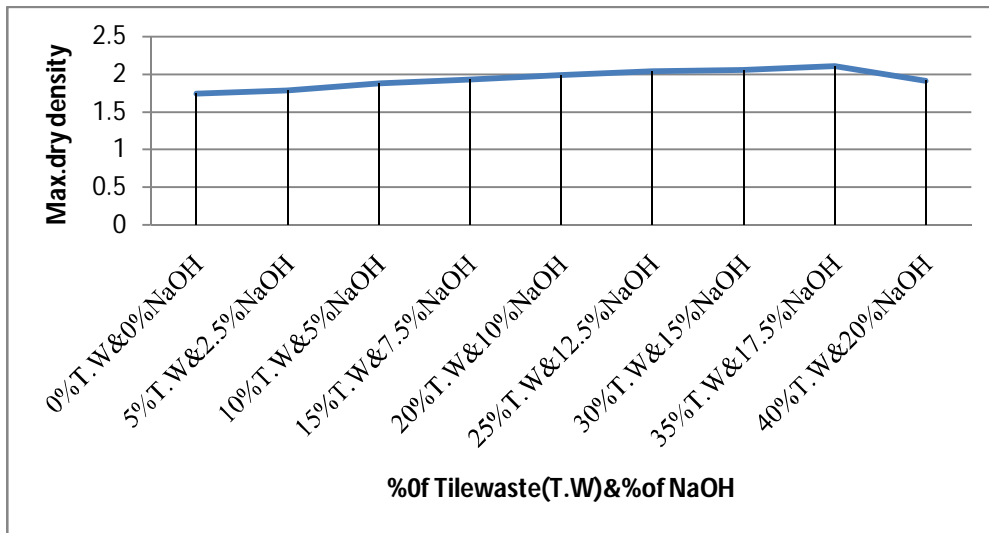


Fig.3 Variation of maximum dry density on different percentage of tiles waste & NaOH

From the fig.3 it can be evaluated that the addition of tile waste and NaOH increases maximum dry density from 1.74 to 2.108. The optimum moisture content increases with addition of tiles waste and sodium hydroxide.

### 6.3. DIRECT SHEAR TEST

This test is used to determine the shear strength of the soil with the help of shear box apparatus. The soil sample mixed with varying percentage of tile waste and NaOH and then soil sample is compacted in the shear box held between metal stone and porous plates. The shear box is placed in the shear apparatus and various normal load (0.2, 0.4, 0.6, 0.8 kg respectively) is applied on specimen. The test were conducted as per IS 2720 part 13-1986.

Table.3. Determination of shear stress of sample replaced with varying percentage of tiles waste and NaOH

% of Tile waste	% of NaOH	Shear stress at failure (kg/cm <sup>2</sup> )
5%	2.5%	0.165
10%	5%	0.183
15%	7.5%	0.20
20%	10%	0.22
25%	12.5%	0.238
30%	15%	0.265
35%	17.5%	0.293
40%	20%	0.198

The table 3 shows the value of shear stress with varying percentage of tiles waste and NaOH. From the table it can be seen that the shear stress gradually increases with the addition of tiles waste upto 35% and NaOH upto 17.5% and decreases beyond this limit.

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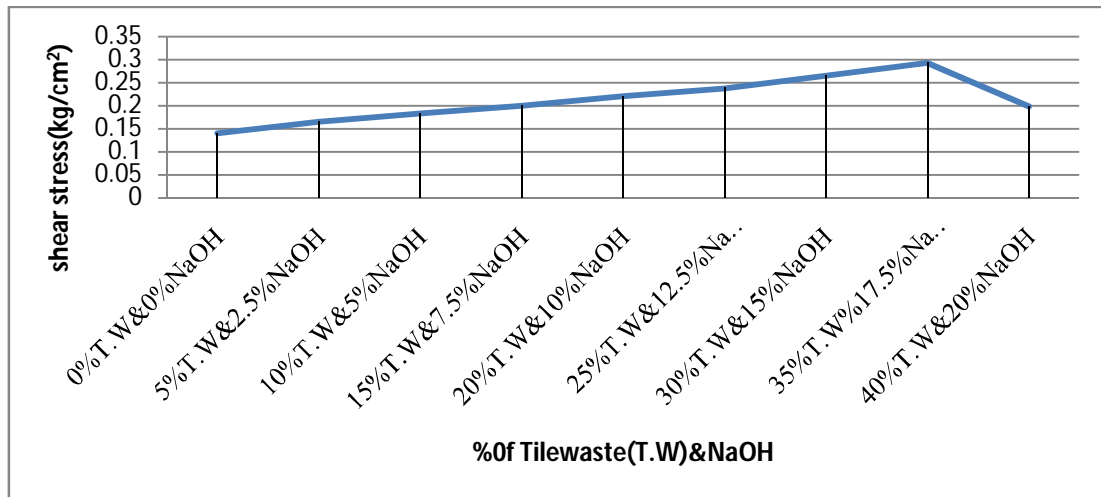


Fig.4 Variation of shear stress on different percentage of tiles waste & NaOH

From the fig4 it can be seen that the shear stress increases with in percentage of tile waste up to 35% and NaOH up to 17.5% and the shear stress decreases beyond this limit.

## 6.4. CALIFORNIA BEARING RATIO TEST

This test is used to determine the California Bearing Ratio (C.B.R) of a compacted soil sample in unsoaked condition. The clayey soil is mixed with varying percentage of tile waste and NaOH and then the soil is compacted in the mould and load is applied and reading is taken at penetration of 0.5, 1, 1.5, 2, 2.5, 5, 7.5, 10, 12.5mm respectively.

Table.4 Determination of CBR value of sample replaced with varying percentage of tiles waste and NaOH

% of Tiles waste	% of NaOH	CBR value(@ 2.5mm penetration)
5%	2.5%	3.86
10%	5%	4.16
15%	7.5%	5.94
20%	10%	9.6
25%	12.5%	12.3
30%	15%	12.48
35%	17.5%	16.19
40%	20%	4.60

The table 2 shows the value of CBR value at 2.5mm penetration with varying percentage of tiles waste and NaOH. From the table it can be seen that the CBR gradually increases with the addition of tiles waste upto 35% and NaOH upto 17.5% and the CBR value decreases beyond this limit.

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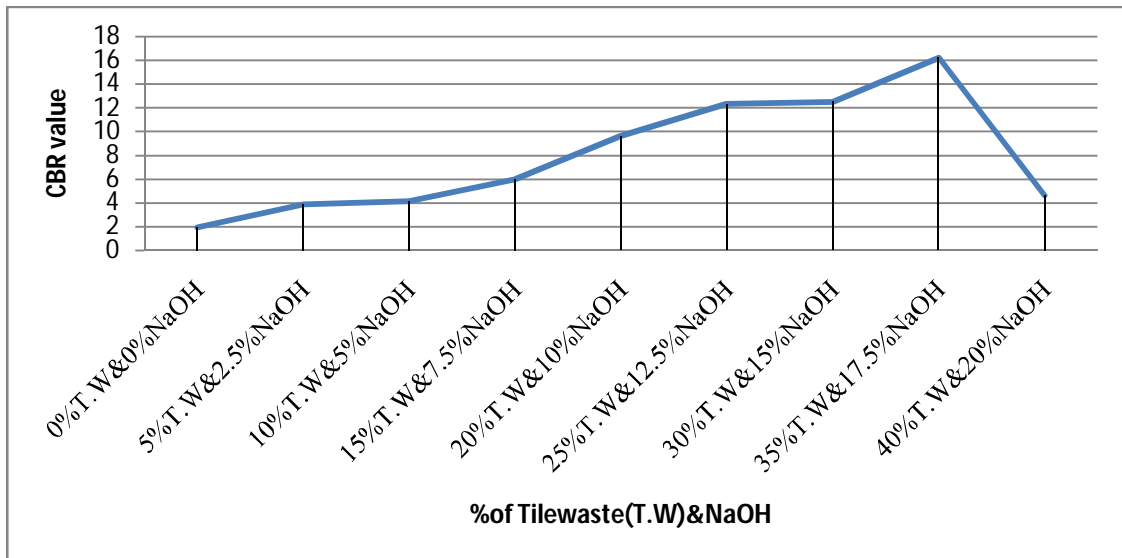


Fig.5 Variation of CBR value on replacement of % of tiles waste & % NaOH

From the fig5 it can be seen that the CBR value increases from 1.93 to 16.19% with the addition of tile waste up to 35% and sodium hydroxide up to 17.5%. The CBR value decreases beyond this limit.

## VII. CONCLUSION

A series of laboratory test is conducted on selected soil sample to study the effect of tiles waste and sodium hydroxide on the soil. Based on the laboratory results, the following conclusions were made,

- The addition of tiles waste and NaOH decreases the liquid limit and plastic limit of the soil up to 35% and it increases beyond this limit.
- The addition of tile waste and sodium hydroxide changes the soil group from CI to ML according to IS 1498-1970.
- MDD increase with increase in 1% of tile waste and NaOH
- In direct shear test, the shear stress increases with in 5 of tiles waste and NaOH. Up to 35% of tile waste and 7.5% of NaOH and tend to decrease beyond this limit.
- The CBR value increase with increase in addition of tile waste and NaOH.

From the above results, it can conclude that addition of tile waste up to 35% and NaOH up to 17.5% is recommended.

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