SOIL STABILZATION BY USING SODIUM SILICATE AND MARBLE DUST

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Abstract : This research paper deals about the experimental study on the stabilization of soil using sodium silicate and marble dust. A series of tests to find compaction properties and unconfined compressive strength have been conducted. The effect of (0, 2, 3, 4, 5, 6) percentages of sodium silicate combined with (0, 2, 4, 6, 8) percentages of marble dust has been studied. All the samples are cured for 14 days. Negatively charged silicate in sodium silicate and positively charged calcium in marble dust will react and will form calcium silicate in gel form which will bind clay soil and increase its strength. Moreover marble dust is waste material. These both materials unlike cement are non-toxic and environment friendly. The results show that unconfined compressive value and maximum dry density of the soil increases whereas OMC of soil decreases highly.

Index terms **– Sodium silicate, Marble dust, Compaction, Stabilization**

1. INTRODUCTION

1.1. General

In past years, the soil stabilization technique was used to improve the different types of soil properties. It was established to stabilize the weak soil for the civil engineering projects. In past times, for the stabilization lime, bitumen, aggregates etc. are used. But in present times, the industries and factories waste materials are used for the stabilization of the soil. Because it causing the problem of dumping and other environmental problems. The soil properties are depends upon the size of the parties, bearing capacity and drainage conditions. For civil engineer, making the safe and economical structures is bigger task. The study also aims to investigate the effect to combining sodium silicate with the industry waste marble dust on the engineering properties of stabilized soils.

1.2. Sodium silicate

Sodium silicate is colorless transparent solids, white powders and water soluble. It is produced by the chemical fusion of soda ash and silica sand. Sodium silicate is a compound which containing sodium oxide and silicon dioxide. It has used into various manufacturing, industrial, agricultural. Some of the manufactures prefers as an adhesive material, because of its low cost, non-toxic and environmentally friendly.

Table 1 Chemical composition of sodium silicate

Chemical formula	**$(Na_2O)_x \cdot SiO_2$**
Appearance	Thick liquid.
Color	Clear to murky white.
Odor	Odorless or musty odor.
pH	10 – 15
Density	1.4 – 1.6 g/cubic cm
Water soluble	100%

1.3. Marble dust

Marble is a recrystallize carbonate materials, which consists of calcite and dolomite. Marble may be considered as metamorphosed limestone. The fine particles less than 2 mm are produced, when marble cutting. Marble dust is used in brick, building material, infiltration, ceramic processes. Increasing the utilization ratio of such wastes appear to be a solution to environmental problems and will decrease the construction costs.

Table 2 Chemical composition of marble dust

CaO	55.4
SiO_2	2.31
SO_3	0.61
MgO	0.54
Al_2O_3	0.19
Fe_2O_3	0.07
Na_2O	0.03
K_2O	0.01
Mn_2O_3	0.01
TiO_2	0.01
Loss on ignition at 1000 °C	40.81

1.4. Literature review

Wani Ahmad Muzaffar et al. (2017) researched on soil stabilized with lime and sodium silicate. They are added 0 to 6.5% lime and 0 to 3.5% sodium silicate in the soil and concluded that the M.D.D. decreased and O.M.C. increases with the addition of lime and sodium silicate into the soil. The uncured sample of soil with the addition of 4.5% lime and 2.5% sodium silicate mix U.C.S. increased by 129% as compared to virgin soil. The cured sample of soil with the addition of 4.5% lime and 2.5% sodium silicate mix U.C.S. increased by 162% as compared to virgin soil. The unsoaked and soaked

conditions of soil with the addition of 4.5% lime and 2.5% sodium silicate mix increased by 219% and 197% as compared to virgin soil.

Faizal Pakira et al. (2015) were conducted study on effect of liquid based sodium silicate stabilizer on shear strength of marine clay soil. In this study 3% to 6% sodium silicate added into soil and cured it at 0, 3,7,28 days. Sodium silicate decreases the L.L., increases the P.L. of soil and decreases plastic index. The optimum % was found to be 6% of sodium silicate. U.C.S. of soil increases with the different duration curing of samples. The optimum % were found to be 6% of sodium silicate.

M. Yurdakul et al. (2017) explained the effect of marble dust in an expansive soil. As we know, that expansive soils cause lot of damage to structures. These soils swell and shrink when water is added or removed from it respectively. Several chemicals have been used to overcome this swelling behaviour of soil. They added marble dust from 0% to 40% in expansive soil with an increment of 5%. Samples mixed with marble dust were cured samples for 7 and 28 days. The tests were performed like- Atterberg limits, U.C.S. and compaction test were tested. The marble dust effect was positively on the geotechnical properties of soil. The optimum % of expansive soil was found to be 40%. The samples were curing also effects the strength of soil, more curing gave more strength to the soil.

V.K. Arora et al. (2017) explained the effect of marble dust in non-plastic silts. According to them, the best way of stabilize the soil is-using industrial waste. Marble dust is obtained from marble industry which is economical or environment friendly. The overall cost of the project reduces with the cost reduction of soil stabilization. Marble dust is completely free material which can be used to stabilize silt soil in very low price. In their research they found that optimum % of M.D. is found to be 15%. The maximum U.C.S. of the soil is obtained at addition of 15% marble dust, after that the strength of non-plastic silt goes on decreasing. The M.D.D. of soil decreases whereas the non-plastic silt soil O.M.C increases with addition of M.D. in it. From U.C.S. test, they found that the soil becomes brittle with addition of more than 5% marble dust.

2. Materials

2.1. Clay soil

The sample of soil is collected from the nearly located village Pamal in Ludhiana district. The soil is blackish grey in colour. The soil sample was taken carefully at the depth 1 to 3 m, so to avoid undesirable materials.

Sr. No.	Parameters of soil	Values
1.	Specific gravity	2.52
2.	Atterberg limits L.L. % P.L. % P.I. %	 45 21 24
3.	Soil classification	CI
4.	Bulk density	20.4KN/m³
5.	Standard proctor test :- Dry density, γ OMC %	 17.6KN/m³ 16
6.	UCS	87.21 kN/m²

2.2. Sodium silicate

The sodium silicate was bought from locally located chemical store, New Punjab foundry store, Ludhiana. The sodium silicate is in the form of dense liquid which is water soluble.

2.3. Marble dust

The marble dust is taken from locally located marble factory, Ludhiana, Punjab. The marble dust obtained from the cutting of marble pieces. This marble dust is in the form of finest particles like powder.

3. Results

3.1. Effect of sodium silicate

3.1.1. Standard proctor test

This tests are evaluating for the M.D.D. and O.M.C. by mixing of sodium silicate into the soil sample. The addition of 2%, 3%, 4%, 5% and 6% of sodium silicate, at different water content to find out the M.D.D. and O.M.C., after the mixing into the soil.

The O.M.C% directly proportional to different ratio of sodium silicate. The O.M.C % does not change with addition upto 4% sodium silicate, and then decrease after 4% S.S. The O.M.C. decreases with the addition of sodium silicate, due to decrease of voids in the soil. The max. dry density is directly proportional to different ratio of sodium silicate. The dry density increases with the mixing of sodium silicate.

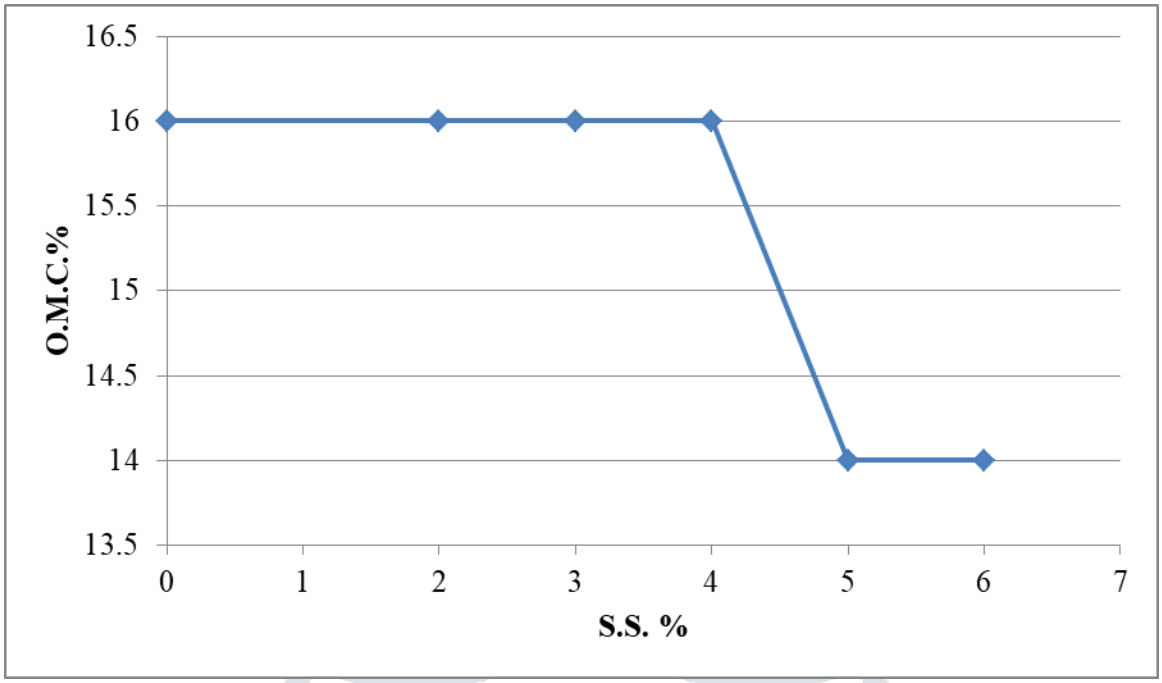

Figure 1 Effect of sodium silicate on O.M.C.

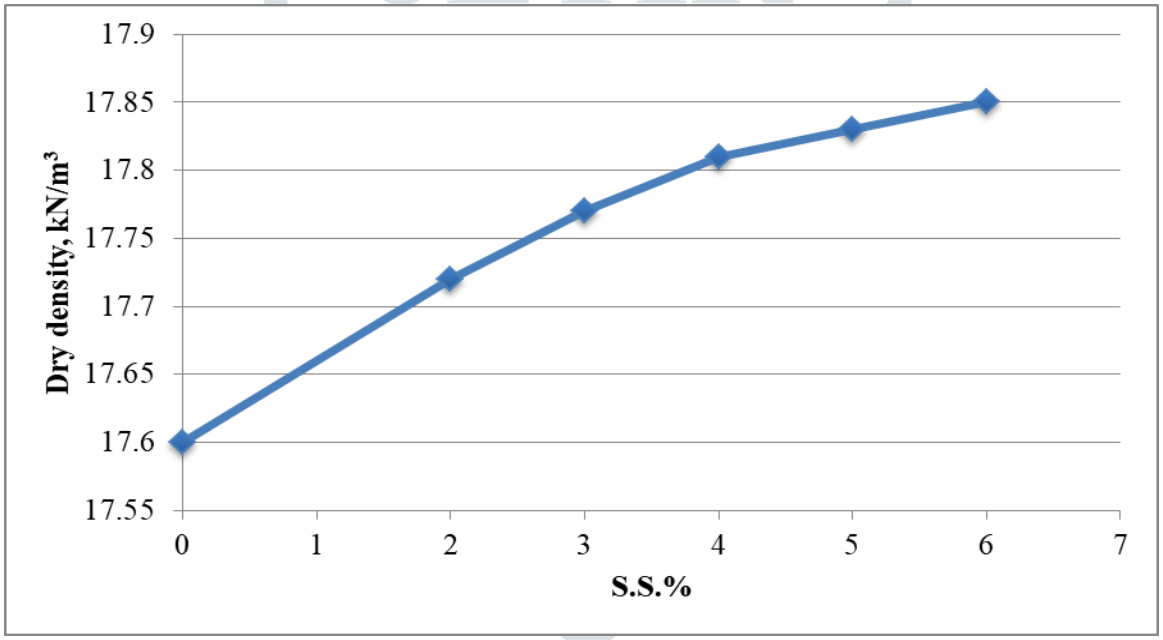

Figure 2 Sodium silicate effects on M.D.D.

3.1.2. Unconfined compressive strength

The sodium silicate was mixed with soil into different proportions 2, 3, 4, 5 and 6 and cured it for 14 days. The U.C.S. increases upto addition of 3% sodium silicate, then the U.C.S. decreases after addition of 4% sodium silicate. For example, for 14 days curing duration, the U.C.S. increases from 97.56 kN/m^2 to 191.11 kN/m^2 with the addition 2% sodium silicate increases to 3% but the strength decreases to 184.76 kN/m^2 with the addition of 4% S.S.

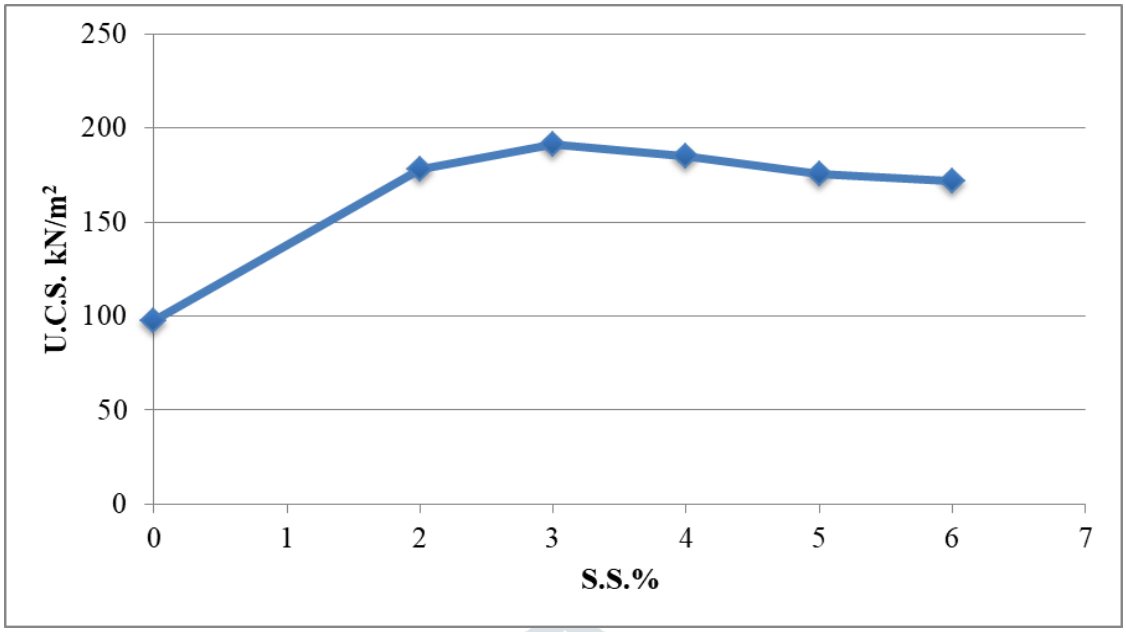

Figure 4 Effect of sodium silicate on U.C.S.

With increments of sodium silicate will increases compressive strength of soil. The increment is formed due to the behavior of water stabilizers, with the increment of S.S. and moisture content of soils. Taking 3% sodium silicate as an optimum value of U.C.S. is 191.11 kN/m^2

.3.2. Effect of marble dust

3.2.1. Standard proctor test

The test is performed to investigate the M.D.D and O.M.C. by mixing the sodium silicate into the soil sample. The addition of sodium silicate is 2%, 4%, 6% and 8% at the different water content.

The O.M.C% directly proportional to different ratio of marble dust. The O.M.C % does not change with addition upto 4% sodium silicate, and then decrease after 4%. The max. dry density is directly proportional to different ratio of marble dust. The M.D.D increases with the addition of M.D.

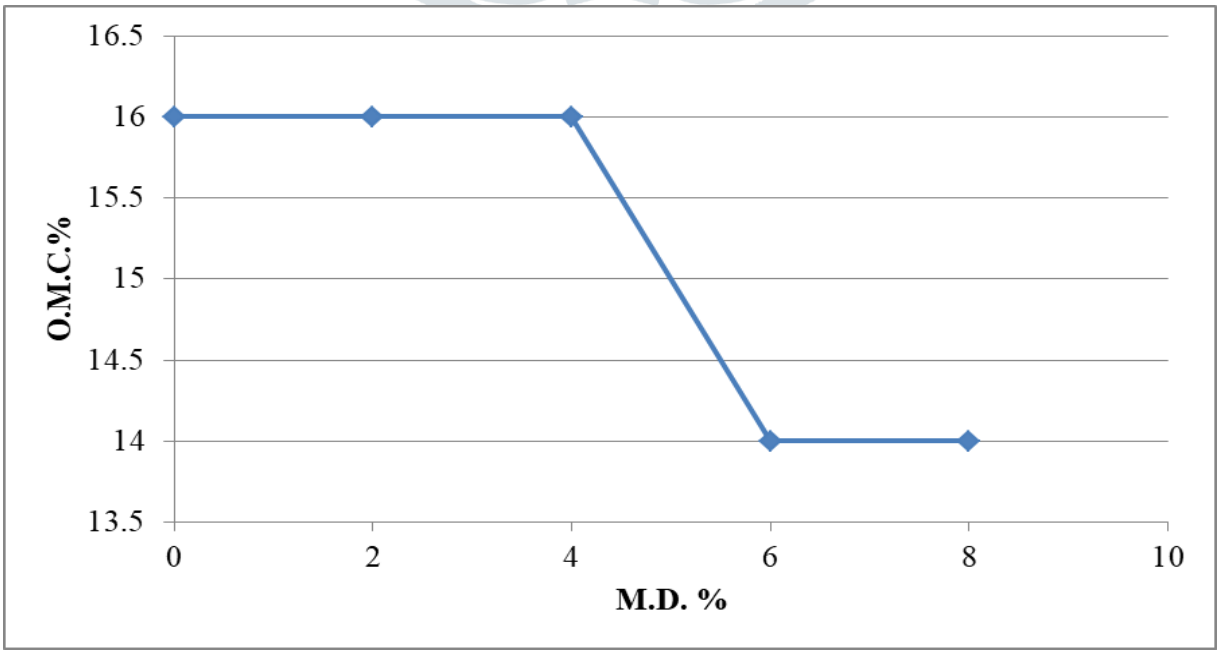

Figure 4 Effect of marble dust on O.M.C

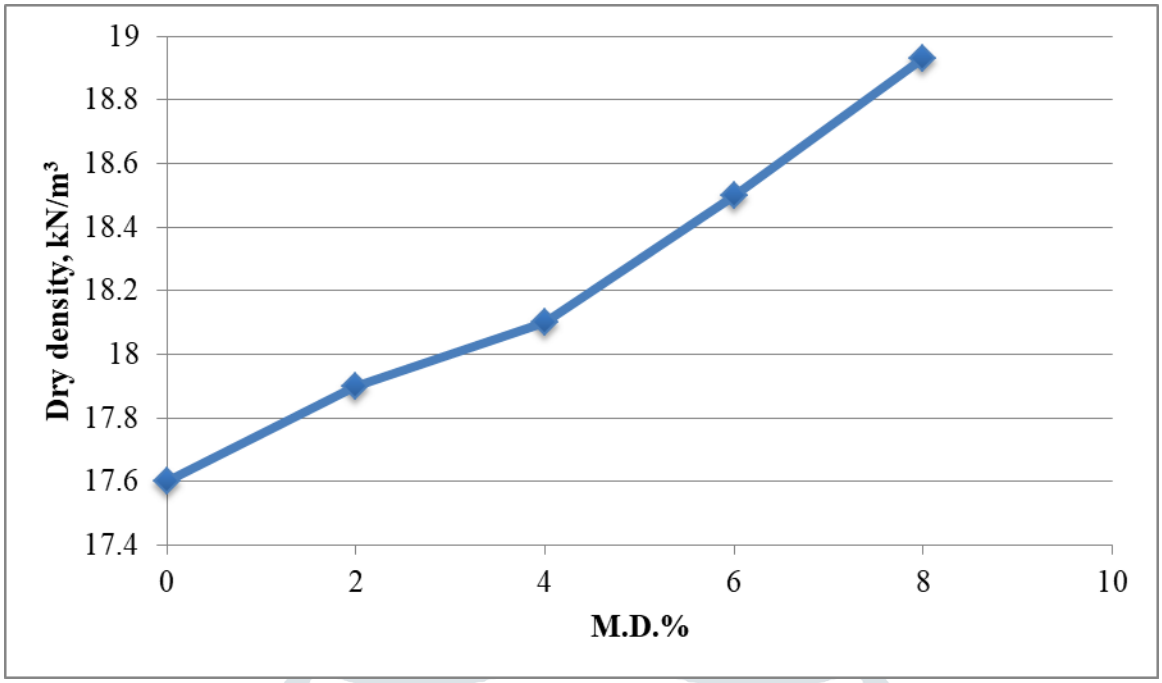

Figure 5 Effect of marble dust on maximum dry density

3.2.2. U.C.S. test

The sodium silicate was mixed with soil into different proportions 2,4,6,8 and cured it for 14 days. The U.C.S. increases upto addition of 6% marble dust, then the U.C.S. decreases after the addition of 8% marble dust. Taking the 6% dust is as an optimum value of U.C.S. is 140.16 kN/m^2.

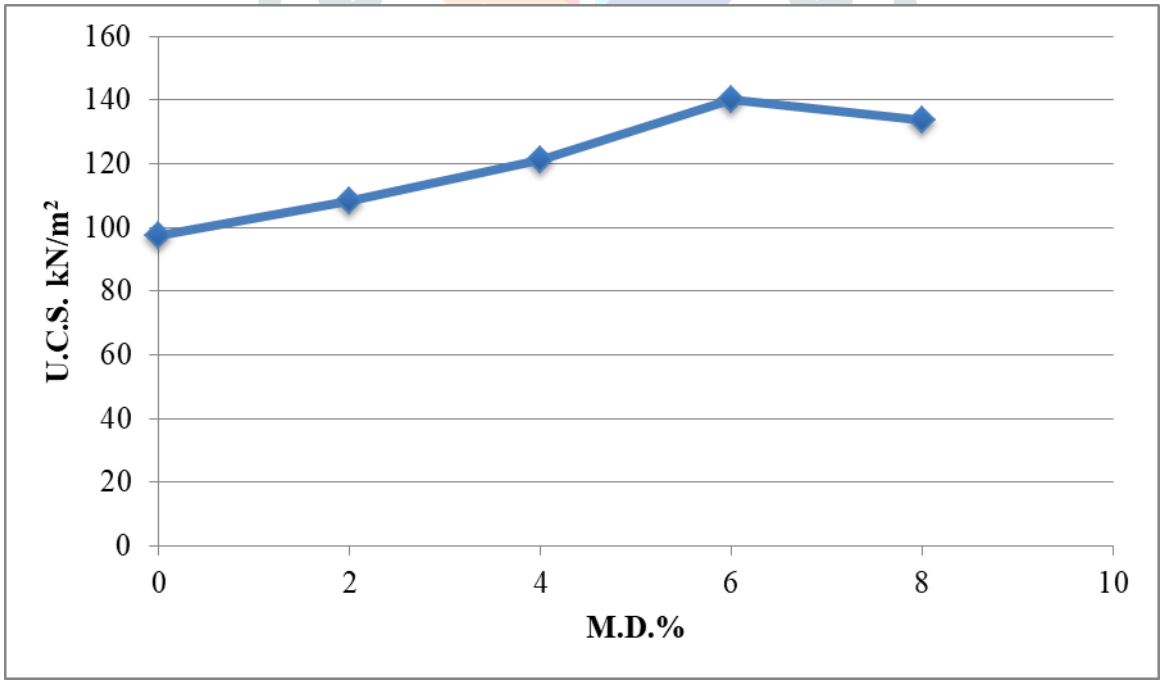

Figure 6 Marble dust effect of on U.C.S

3.3. Combined effect of sodium silicate and marble dust

3.3.1. Standard proctor test

This test is performed to investigate the M.D.D and O.M.C. by mixing the sodium silicate and M.D. into the soil. The addition of optimum 3% sodium silicate and 2%, 4%, 6% and 8% marble dust at the different moisture content.

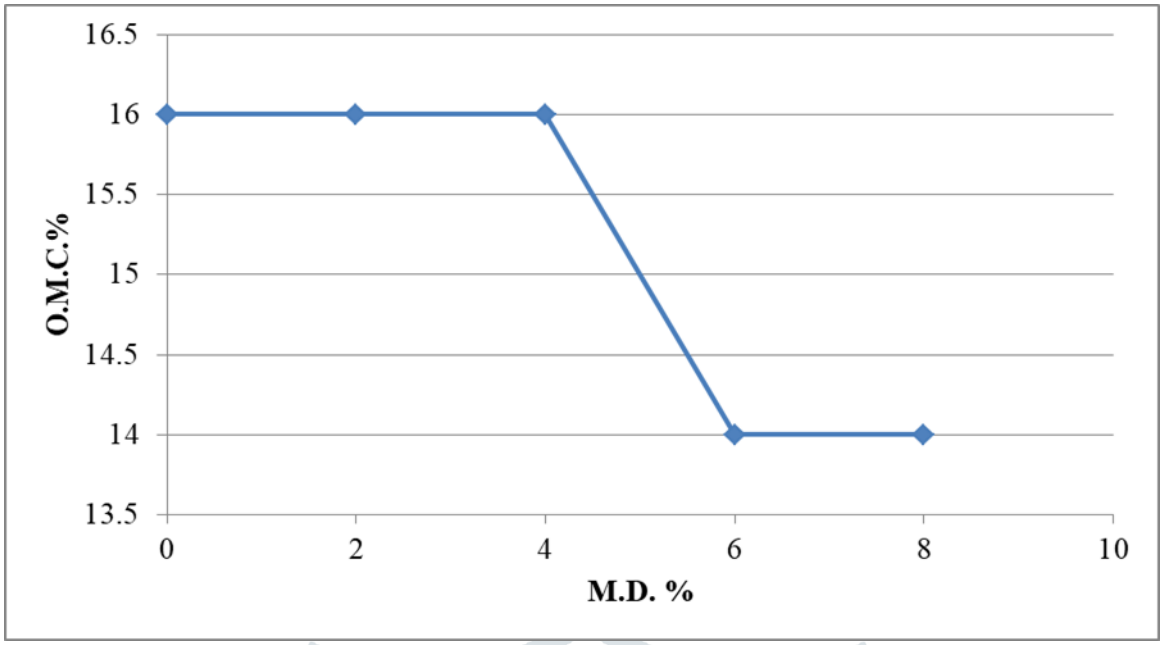

Figure 7 Sodium silicate and marble dust effect on O.M.C.

This graph shows in figure 4.28, the O.M.C % does not change if the optimum 3% sodium silicate addition upto 4% marble dust and then decrease after 4%. The M.D.D. increases with the addition of the optimum 3% of sodium silicate and different ratio of M.D.

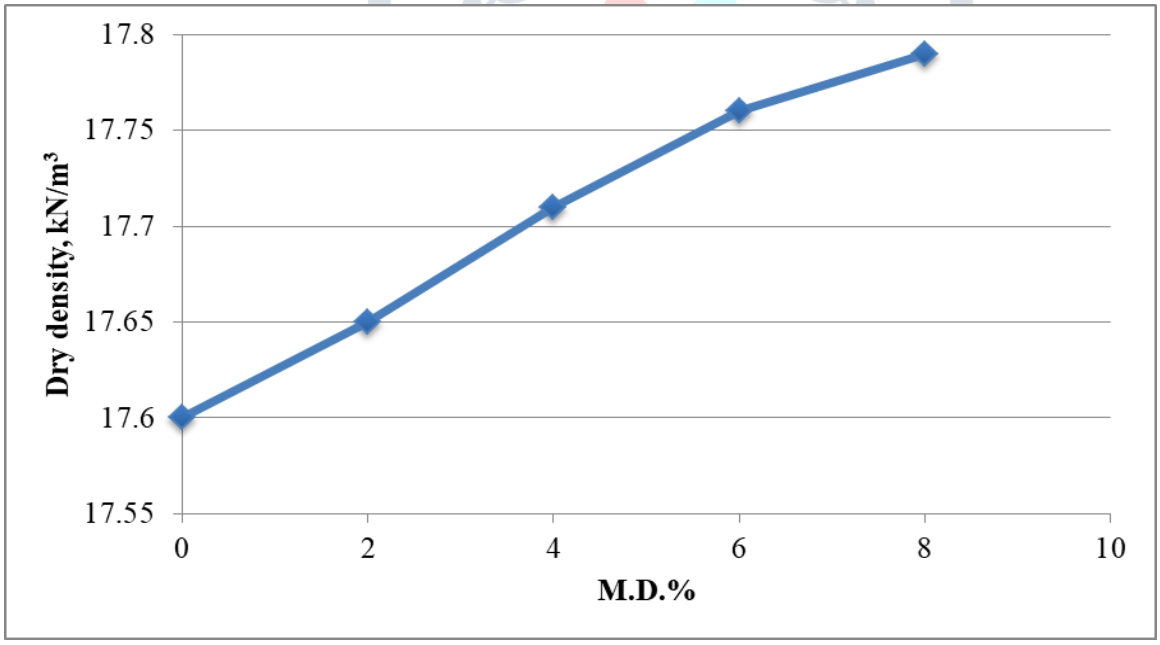

Figure 8 Sodium silicate and marble dust effect on maximum dry density

3.2.2. U.C.S. test

The graph shows that the U.C.S. increases upto the addition of 2% marble dust with the optimum 3% sodium silicate, then the U.C.S. decreases after addition of 3% marble dust. The U.C.S. is 216.61 kN/m^2.

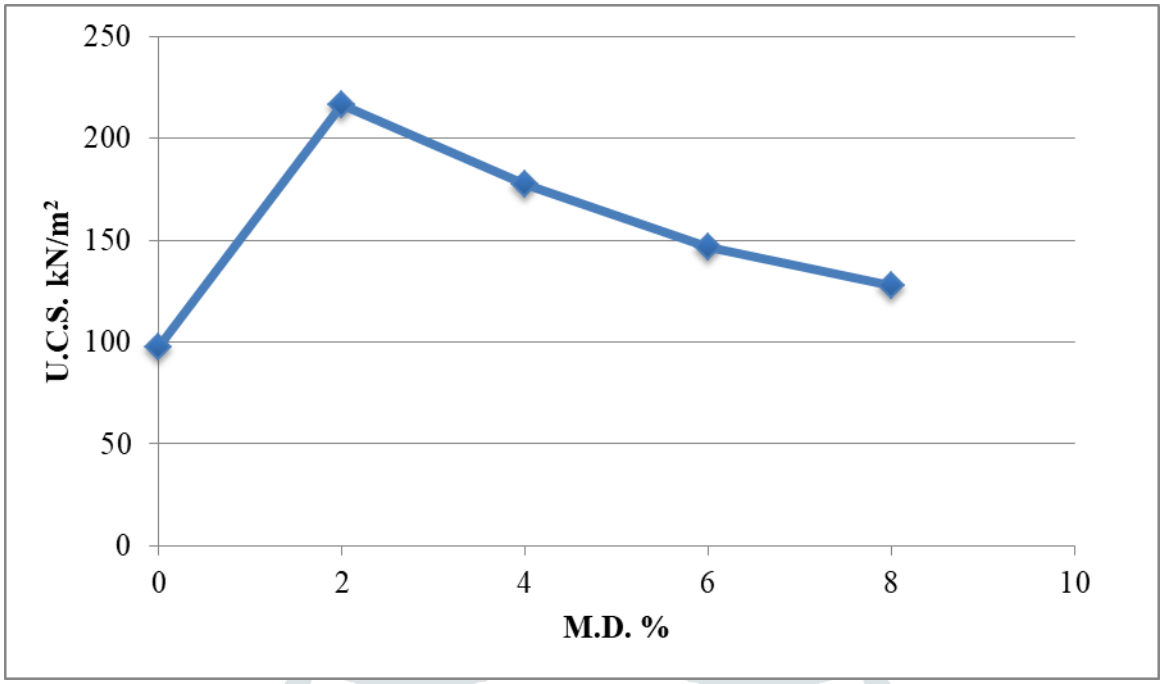

Figure 9 Sodium silicate and marble dust effect on U.C.S.

4. Conclusions

1. The maximum dry density of soil increases with addition of sodium silicate and marble dust whereas the O.M.C. of soil decreases with addition of sodium silicate and marble dust.
2. The U.C.S. of soil increases with addition of sodium silicate and marble dust.
3. The optimum percentage of sodium silicate and marble dust to stabilize soil are found to be 3% and 2% combined respectively.

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