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AN EXPERIMENTAL STUDY ON THE PERFORMANCE OF THE MARINE CLAY STABILISED WITH SEASHELL POWDER AND SODIUM SILICATE AS A SUBGRADE FOR THE FLEXIBLE PAVEMENTS

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Abstract— Roads are the arteries through which Indian economy grows. India is a country which is having a coastal corridor of 7516.6 kms. This coastal region mostly consists of marine clay deposits. For the construction of roads using locally available materials and soils will be economical. But in coastal region using marine clay (locally available soils) as sub grade will not yield desirable results due to its poor engineering properties. Removing and replacing of this soil is not economically feasible as it increases the budget of the project. In this region, as huge quantity of sea shells which are having high percentage of CaO, can be used as stabilizing material for improving the properties of soil. In this experimental study, under controlled conditions through laboratory tests, the efficacy with Sea Shell Powder and Sodium Silicate used for improving the properties of marine clay to suit it as sub grade for the flexible pavements has been studied.

Keywords— Marine clay, Sea Shell Powder, Sodium Silicate, MDD, OMC, CBR.

1. INTRODUCTION

In the construction of pavements, the sub grade plays a pivotal role. Sub grade performance will influence the life span of the pavement. It is essential to select suitable soil to be used as sub grade for flexible pavement for excellent serviceability. Poor performance of sub grade leads pavement distress. To resolve this problem, different methods have been developed for improving the characteristics of sub grade. Marine clay is one of the problematic soils which can be found on coastal region. Marine clay is microcrystalline in nature and it has clay minerals like Illite, Chlorite and Kaolinite. Marine clay tends to become stiff on drying but becomes soft when on wetting. High compressibility and low shear strength (Dr D.Koteswara Rao et la.,(2012)) are the properties of marine clay. One of stabilization method of stabilizing weak soil is replacing weak soil particles with rich soil particles but this particular method is uneconomical. So to avert this problem and for improving soft soils there are different methods in one which stabilization of soil with using ad mixture (industrial by-products) and some additives chemical is considered as economical.

In present study, Sea Shell Powder and Sodium Silicate are added to marine clay to evaluate its performances through laboratory tests such as modified proctor test and California bearing ratio to test its suitability as sub grade for the flexible pavements.

2. REVIEW OF LITERATURE

Dr D.Koteswara Rao et la.,(2012) studied the performance of Marine clay when stabilized with Saw Dust and lime to evaluate its suitability for the pavement sub grade. The effect of Sea Shell Powder on black cotton soil was studied by K.Mounika et al.,(2014)..Maheshwari.G.Bisanal et al.,(2015) stated that stailization of black cotton soil with Sea Shell Powder to reduces the plastic indices .DSV Prasad et al., (2016) reported that Marine Clay when treated with various percentages of quarry dust as an admixture and Ferric chloride as additive improved the load carrying capacity of treated marine clay.

3. OBJECTIVES OF STUDY

The objectives of present experimental study are as follows

- To determine properties of the marine clay.
- To evaluate performance of the marine clay when treated with Sea Shell Powder as an admixture.
- To determine suitability and performance of marine clay when stabilized with an optimum % of Sea Shell Powder on percentage variation of Sodium Silicate as sub grade for flexible pavements.

4. MATERIAL USED

A. Marine clay (MC)

The marine clay which was used in this study was collected from a dredging site, where dredging was carried out at a depth of 2-4 m below the Sea-bed level in Kakinada, Kakinada deep water port ltd. The collected soil was black in color. The presence of sea shells indicates the presence of organic content.

TABLE-1
GEOTECHNICAL PROPERTIES OF THE UNTREATED MARINE CLAY

s.no	Properties		Marine clay
1	Soil classification	Gravel (%)	0
		Sand (%)	17
		Silt (%)	26.20
		Clay (%)	56.80
2	Liquid limit (%)		76.00
3	Plastic limit (%)		27.61
4	Plasticity index (%)		48.39
5	Soil classification		CH
6	Specific gravity		2.31
7	Differential free swell (%)		90
8	MDD(g/cc)		1.412
9	OMC (%)		32.00
10	CBR (%)		1.344
11	cohesion(kN/m^2)		90
12	Angle of internal friction		3.12^0

B. Sea Shell Powder

The sea shells were collected from the Kakinada market yard, deep water port kakinada. The collected shells were cleaned, dried, burnt in brick furnace. These burnt sea shells were crushed into small pieces using Los Angeles testing machine, then grounded with a blender, and sieved using 150 micron sieve to produce seashell powder to use in stabilization. The Sea Shell Powder mainly consists of 51.56% CaO and 1.60% SiO2.

TABLE 2
CHEMICAL COMPOSITION OF SEA SHELL POWDER

S.No	Oxide	Percentage
1	SiO_2	1.60
2	Al_2O_3	0.92
3	CaO	51.56
4	MgO	1.43
5	Na_2O	0.08
6	K_2O	0.06
7	H_2O	0.31
8	LOI	41.84

Courtesy to Monita Oliviaa, Annisa Arifandita Mifshella, Lita
Universitas Riau, Kampus Bina Widya Simpang Baru, Pekanbaru Riau 28293, Indonesia

C.Sodium Silicate

Sodium Silicate also called as water glass or soluble glass is a compound containing sodium oxide and silica. The commercial product is available in powder form and also available in liquid form. Sodium Silicate was collected from Associated Scientific Company, Kakinada.

5. LABORATORY STUDIES

The laboratory studies were carried out on the Marine clay, Marine clay treated with percentage variation of Sea Shell Powder and Marine clay treated with optimum percentage of seashell powder on percentage variation Sodium Silicate.

Liquid limit
Liquid limit test was performed on Marine clay, Marine clay+18% seashell powder and Marine clay+18% seashell powder & 1% Sodium Silicate using Casagrande's liquid limit apparatus as per the procedures laid down in IS: 2720 part 4 (1970).table last

Plastic limit
Plastic limit test was performed on Marine Clay, Marine Clay+18% Seashell powder and Marine clay+18% Seashell powder & 1% Sodium Silicate as per the specifications laid down in IS: 2720 part 4 (1970).

Differential free swell
Differential free swell test was performed on Marine Clay, Marine Clay+18% Seashell powder and Marine clay+18% Seashell powder & 1% Sodium Silicate as per the specifications laid down in IS: 2720 part 40 (1977).

Modified Proctor compaction Test
The optimum moisture content and maximum dry density have an important role in changing the strength properties of soil. Test was performed on Marine clay, Marine clay & varying percentages of Sea Shell Powder and Marine clay treated with optimum of 18% Sea Shell Powder & varying percentages of Sodium Silicate as per IS: 2720 part-6 (1974).

Specific Gravity Test
Specific Gravity Test was performed on Marine Clay, Marine Clay+18% Seashell powder and Marine clay+18% Seashell powder & 1% Sodium Silicate using density bottle test as per IS 2720 Part 3 (1980).

California Bearing Ratio Test
The California bearing ratio tests are conducted on Marine Clay, Marine Clay treated with Sea Shell Powder and Marine clay with optimum of Sea Shell Powder & percentage variation of Sodium Silicate mixtures as per IS 2720 part 16 (1979).

6. Results and discussion

1. Modified proctor test and CBR test values of the Marine clay treated with various percentages of Sea Shell Powder
(A) Modified proctor test results of marine clay when treated with various percentage of Sea Shell Powder are in Table 3and figure 1 & 2 present the OMC and MDD graphs for untreated and treated marine clay.

TABLE 3
OMC AND MDD VALUES OF UNTREATED AND TREATED MARINE CLAY

Mix	OMC (%)	MDD(g/cc)
100%soil	32.00	1.412
95%soil+5% Sea Shell Powder	31.02	1.512
90%soil+10% Sea Shell Powder	28.05	1.521
85%soil+15% Sea Shell Powder	23.54	1.551
82%soil+18% Sea Shell Powder	22.46	1.566
80%soil+20%Sea Shell Powder	27.45	1.545

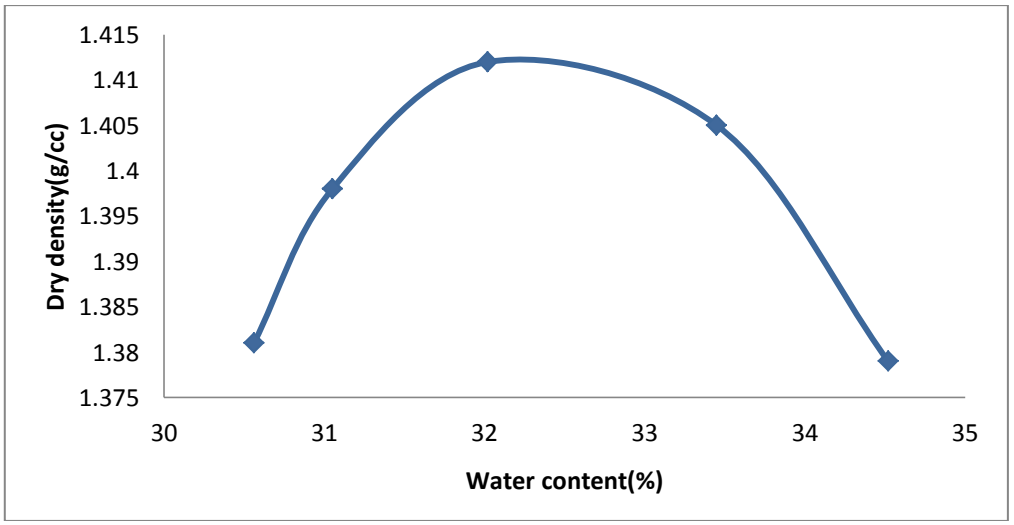

Fig.1 OMC and MDD values of untreated marine clay

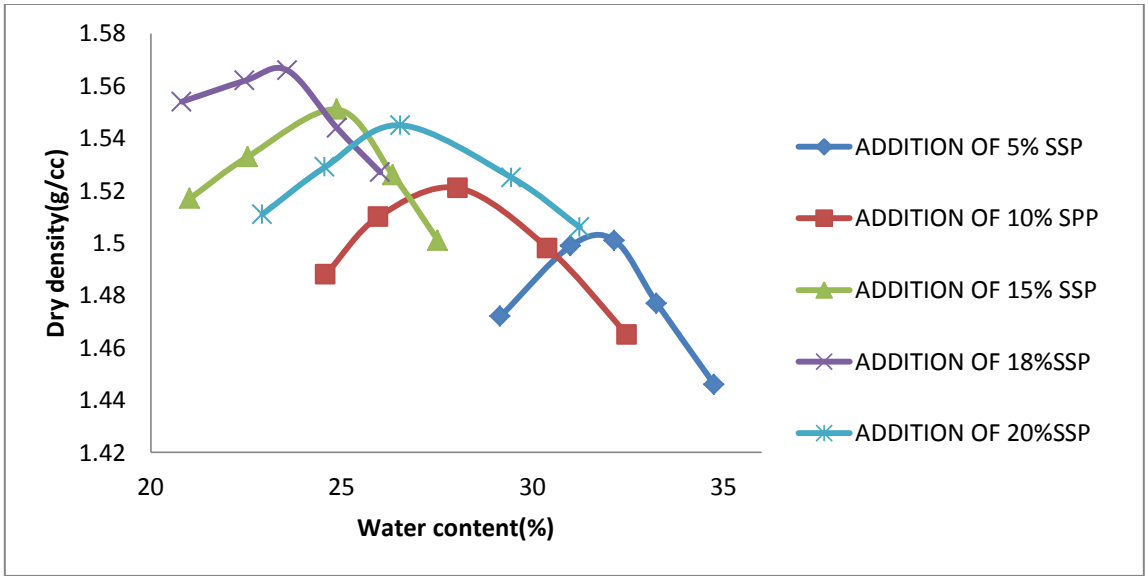

Fig.2 OMC and MDD values of treated marine clay with various percentages

(B)CBR test values

Table 4 and fig. 6 present the CBR values marine clay treated with various percentages of Sea Shell Powder.

TABLE 4
CBR VALUES OF UNTREATED AND TREATED MARINE CLAY WITH VARIOUS PERCENTAGES OF SEA SHELL POWDER

Mix	CBR (%)
100%soil+0% Sea Shell Powder	1.344
95%soil+5% Sea Shell Powder	2.240
90%soil+10% Sea Shell Powder	3.137
85%soil+15% Sea Shell Powder	4.033
82%soil+18% Sea Shell Powder	4.481
80%soil+20% Sea Shell Powder	3.361

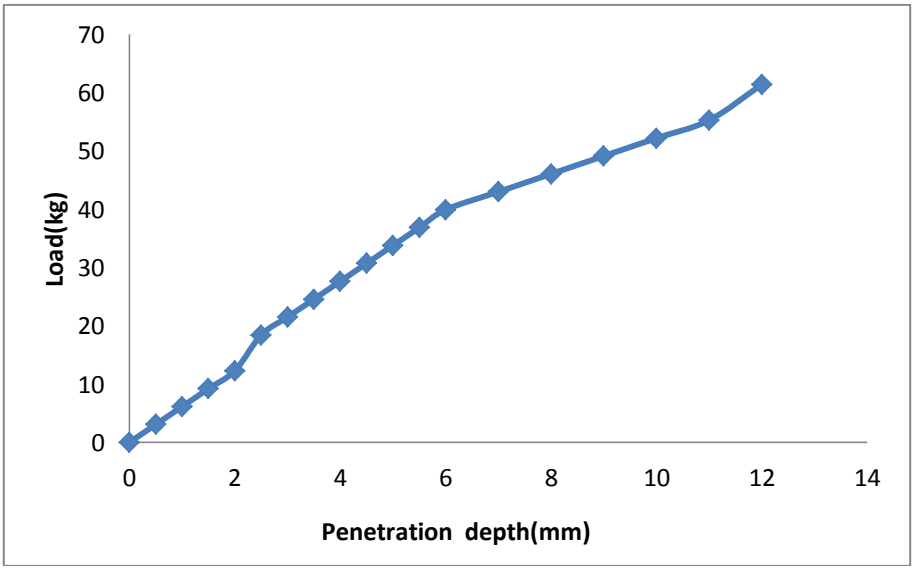

Fig.3 CBR graph of untreated marine clay

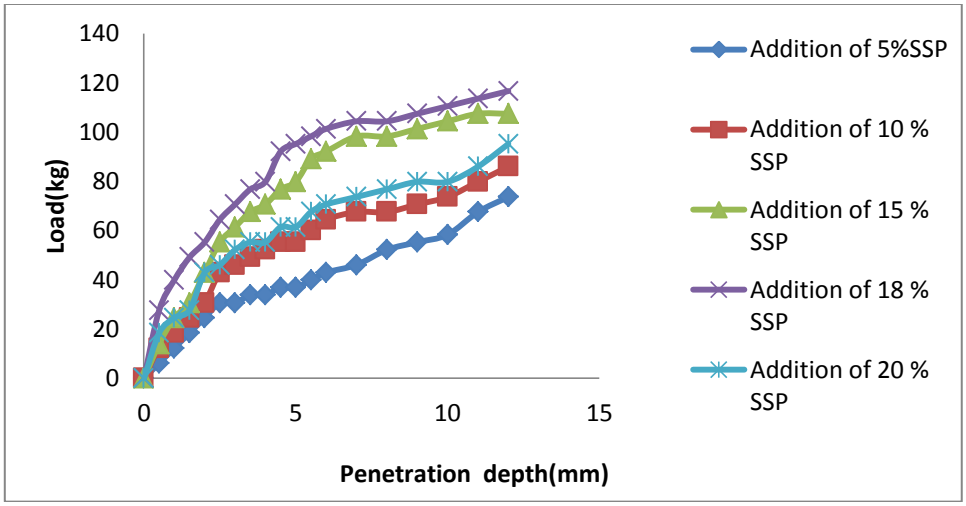

Fig.4 CBR graphs of treated marine clay with various percentage of SEA SHELL POWDER

DISCUSSION-1

It can be observed from the lab results that Marine clay treated with an optimum of Sea Shell Powder was exhibit the CBR value of 4.481 which less as per IRC 37-2012 codes of parties .Further an attempt has been be taken by using Sodium Silicate as an additive for improving this treated marine clay to suit as sub grade for flexible pavement as per IRC 37-2012.

2. Modified proctor compaction test and CBR test values of marine clay + 18% Sea Shell Powder treated with various percentages of Sodium Silicate:-

(A) Modified proctor test results:-

OMC and MDD values of the marine clay+18%Sea Shell Powder treated with various percentages of Sodium Silicate listed in Table 5 and graph are shown in figure 5.

TABLE 5

OMC AND MDD VALUES OF THE MARINE CLAY+18%SEA SHELL POWDER TREATED WITH VARIOUS PERCENTAGES OF SODIUM SILICATE

Marine clay+18% Sea Shell Powder treated with various percentage of Sodium Silicate	OMC (%)	MDD(g/cc)
.5	23.45	1.591
1	21.89	1.597
1.5	24.24	1.594
2	25.00	1.587

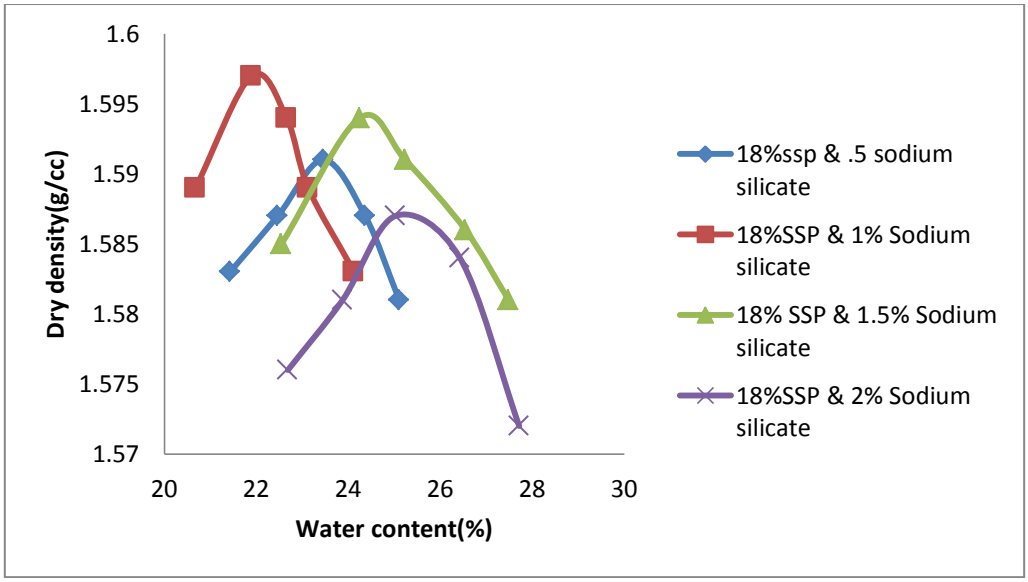

Fig .5Marine clay+18% Sea Shell Powder treated with various percentage of Sodium Silicate

(B)CBR test results

Table 5 and fig. 6 present the CBR values marine clay + 18% Sea Shell Powder treated with different percentages of Sodium Silicate.

TABLE 6
MARINE CLAY+18% SEA SHELL POWDER TREATED WITH VARIOUS PERCENTAGE OF SODIUM SILICATE

Marine clay+18% Sea Shell Powder treated with various percentage of Sodium Silicate	CBR (%)
.5	6.722
1	8.051
1.5	7.170
2	5.378

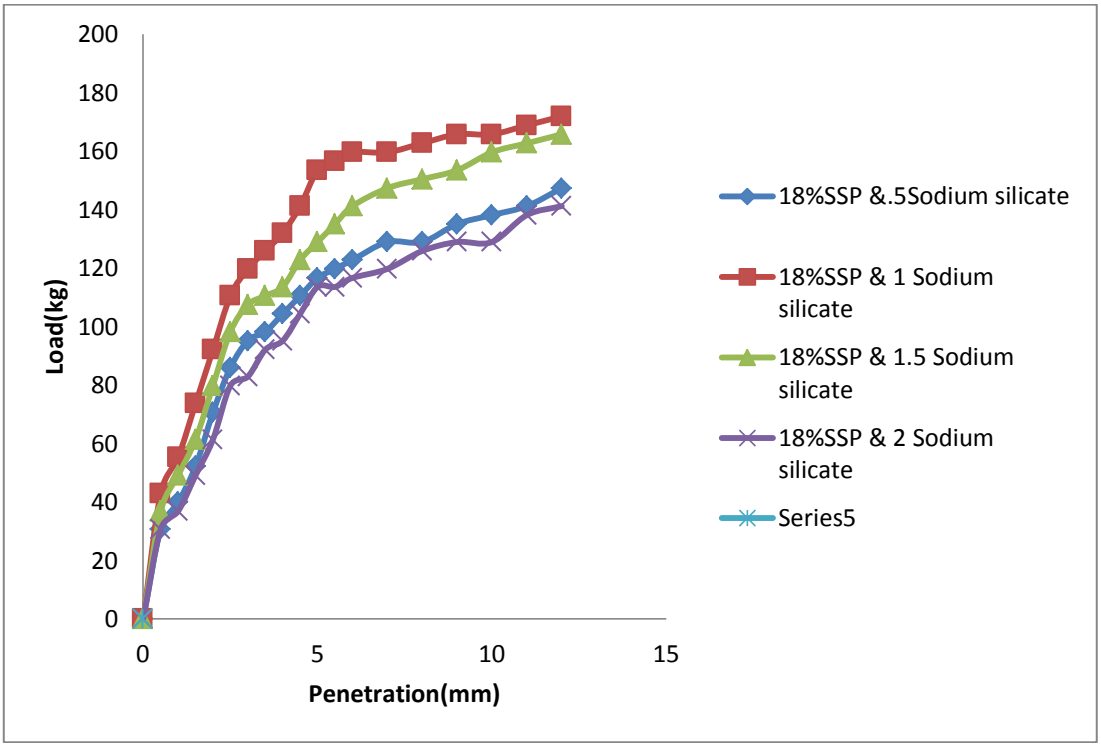

Fig.6 Marine clay+18% SEA SHELL POWDER treated with various percentage of Sodium Silicate

(C) Laboratory tests results of Liquid limit, Plastic limit, Plasticity Index, Compaction, CBR, Specific gravity, Differential Free Swell, Cohesion, angle of shear resistance were conducted on the Marine clay treated with the optimum percentage of SEA SHELL POWDER and Sodium Silicate are as follows:-

TABLE 8
LABORATORY TEST RESULTS OF THE UNTREATED AND TREATED MARINE CLAY

S.No	Properties	Symbol	Marine clay	Marine clay +18%SEA SHELL POWDER	Marine clay+18%SEA SHELL POWDER+1%Sodium Silicate
1	Liquid limit (%)	W_l	76.00	64.00	57.55
2	Plastic limit (%)	W_p	27.61	29.94	30.24
3	Plasticity index (%)	I_p	48.39	34.06	27.31
4	Specific gravity	G	2.41	2.58	2.75
5	Differential free swell (%)	D_f	90	60	44.44

6	MDD(g/cc)	Y_d	1.412	1.566	1.597
7	OMC (%)	W	32.00	22.46	21.89
8	CBR (%)		1.344	4.481	8.051
9	Cohesion(kN/m^2)	C	90	74	55
10	Angle of internal friction	Φ	3.12^0	6^0	10^0

DISCUSSION-2

As per irc37-2012 the CBR value of this treated marine clay is sufficient. Hence this treated marine clay can be used as sub grade for flexible pavements.

7. CONCLUSIONS

1. It is noticed from the laboratory test results that the differential free swell of marine clay has been improved by 33.33% on addition of 18% Sea Shell Powder and differential free swell of this treated marine clay has been improved further 50.62% by addition of 1% Sodium Silicate when compared with untreated marine clay.
2. It is noticed from the laboratory test results that the liquid limit value of marine clay has been improved by 15.78% on addition of 18% Sea Shell Powder and liquid limit value of this treated marine clay has been improved further 28.58% by addition of 1% Sodium Silicate when compared with untreated marine clay.
3. It is observed from the laboratory test results that the plasticity index of marine clay has been improved by 29.61% on addition of 18% Sea Shell Powder and plasticity index of this treated marine clay has been improved further 43.56% by addition of 1% Sodium Silicate when compared with untreated marine clay.
4. It is observed from the laboratory test results that the OMC value of marine clay has been improved by 29.61% on addition of 18% Sea Shell Powder and OMC value of this treated marine clay has been improved further 31.59% by addition of 1% Sodium Silicate when compared with untreated marine clay.
5. It is noticed from the laboratory test results that the Maximum Dry Density(MDD)of marine clay has been improved by 10.90% on addition of 18% Sea Shell Powder and Maximum Dry Density(MDD) of this treated marine clay has been improved further 13.11% by addition of 1% Sodium Silicate when compared with untreated marine clay.
6. It is noticed from the laboratory test results that the CBR value of marine clay has been improved by 233.40% on addition of 18% Sea Shell Powder and CBR value of this treated marine clay has been improved further 499.03% by addition of 1% Sodium Silicate when compared with untreated marine clay.

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