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INFLUENCE OF CALCIUM CHLORIDE ON INDEX PROPERTIES AND CBR VALUE OF CLAYEY SOIL

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KEYWORDS: California Bearing Ratio (CBR), unconfined compressive strength test (UCS), Calcium Chloride, Optimum Moisture content (OMC), Maximum Dry Density (MDD)

ABSTRACT
Most of the problem faced by geotechnical engineers is when a given site does not have suitable engineering properties to support structures, roads and foundation. The soil of the site may be weak due to various reasons. A difficult problem in work exists when the soil is found to be clay or the water table in that region is high. Soils with high clay content generally have low shear strength and has tendency to swell when their moisture content is allowed to increase. For these reasons clayey soil is not suited for structures, roads and foundation. Engineering properties of clayey soil can be improved by adopting different methods of soil stabilization.

Many stabilization methods are in practice for altering the engineering properties of the clayey soil. Common methods for stabilization of clayey soil are lime and cement stabilization. Soil can also be stabilized by chemical stabilization as well as physical stabilization. Physical stabilization includes dynamic compaction and chemical stabilization is done by using chemically active materials such as lime, fly ash, Portland cement, calcium chloride, sodium chloride, sodium silicate, magnesium chloride or materials having elastic properties such as bitumen.

Calcium chloride is the ionic compound of calcium and chloride. A recent study shows that calcium chloride can be effectively dissolves in water quickly and provide enough calcium ions for exchange ionic reactions with clayey soil. Function of this chemical (calcium chloride) is to form into cluster of fine particles and bind them together. Calcium chloride dosage is added in 0.5% to 3.0% by weight of soil with 0.5% of increment in each dosage. Standard proctor test, CBR, consistency limits test and UCS test are performed to determine the optimum dosage of calcium chloride.

INTRODUCTION
India has large geographical area which requires vast number of structures and roads. Availability of land for usage is less due to modernization and urbanization of the country. Land is being used for purpose like housing, roads, highways, bridges, airports, buildings, expressways and other purposes. Construction is taking place over the land which is weak or soft.

Most of the problem faced by geotechnical engineers is when a given site does not have suitable engineering properties to support structures, roads and foundation. The soil of the site may be weak due to various reasons. A difficult problem in work exists when the soil is found to be clay or the water table in that region is high. Soils with high clay content generally have low shear strength and has tendency to swell when their moisture content is allowed to increase. For these reasons clayey soil is not suited for structures, roads and foundation. Engineering properties of clayey soil can be improved by adopting different methods of soil stabilization.

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stabilization is done by using chemically active materials such as lime, fly ash, Portland cement, calcium chloride, sodium chloride, sodium silicate, magnesium chloride or materials having elastic properties such as bitumen.

Calcium chloride is the ionic compound of calcium and chloride. A recent study shows that calcium chloride can be effectively dissolves in water quickly and provide enough calcium ions for exchange ionic reactions with clayey soil. Function of this chemical (calcium chloride) is to form into cluster of fine particles and bind them together. During exchange reactions calcium ions reacts with alkali ions which are present on surface of the clayey soil. These reactions occur because calcium ions are positively charged and have excess of ions in outer shell, which share its ions with negatively charged particles of clay minerals.

Figure 1 Calcium Chloride

Table 1: Properties of calcium chloride

Property	**Value**
Molar mass	110.99 $g.mol^{-1}$
Appearance	White powder
Minimum assay	95%
Iron (fe)	0.002%
Heavy metal (as Pb)	0.002%
Sulfate (SO_4)	0.05%
Loss on drying	10%
Boiling point	1,935 ºC

EXPERIMENTAL RESULTS

- **SOIL-** Properties of the soil are given below:

Table 2: Basic properties of soil

Serial No.	Properties of soil	Value
1	Specific gravity	2.667
2	Liquid limit	39%
3	Plastic limit	28%
4	Plasticity index	11%
5	IS classification	CI
6	Optimum moisture content	16%
7	Maximum Dry density	1.63gm/cc

- **STANDARD PROCTER TEST**

Table 3: standard proctor test results

Serial no.	Dosage	O.M.C (%)	M.D.D (g/cc)
1.	Virgin soil	16	1.63
2.	Soil + 0.5% of $CaCl_2$	16	1.66
3.	Soil +1.0% of $CaCl_2$	15	1.69
4.	Soil +1.5% of $CaCl_2$	14	1.72
5.	Soil +2.0% of $CaCl_2$	13	1.74
6.	Soil +2.5% of $CaCl_2$	12	1.77
7.	Soil +3.0% of $CaCl_2$	13	1.73

- **California Bearing Ratio-**

Table 4: CBR results

Serial no.	Dosage	CBR (unsoaked)	CBR (soaked)
1.	Virgin soil	2.95	1.77

2.	Soil + 0.5% of $CaCl_2$	3.65	2.19
3.	Soil +1.0% of $CaCl_2$	4.36	2.61
4.	Soil +1.5% of $CaCl_2$	5.10	3.06
5.	Soil +2.0% of $CaCl_2$	5.32	3.19
6.	Soil +2.5% of $CaCl_2$	5.86	3.51
7.	Soil +3.0% of $CaCl_2$	5.47	3.28

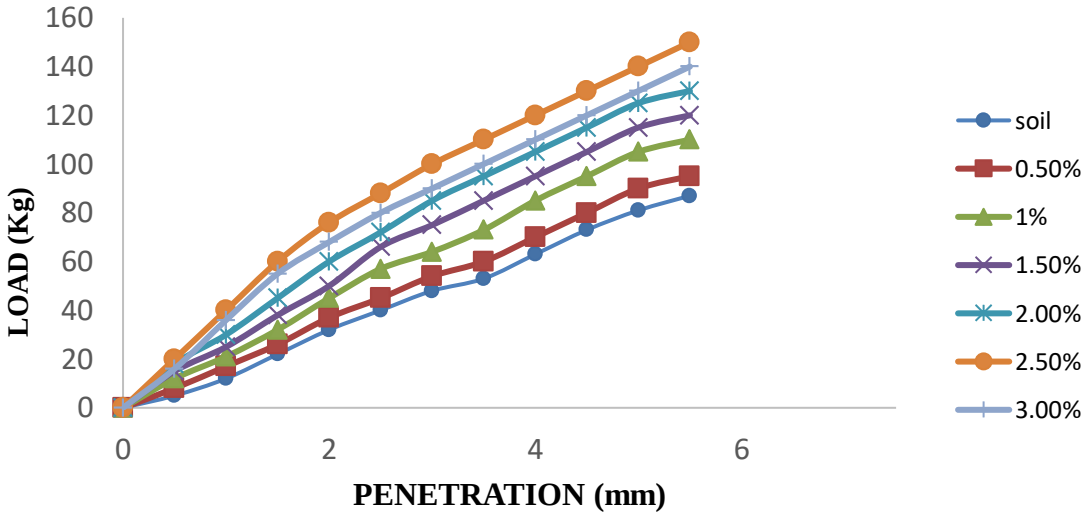

Figure 2: Unsoaked CBR of soil at different dosages of chemical

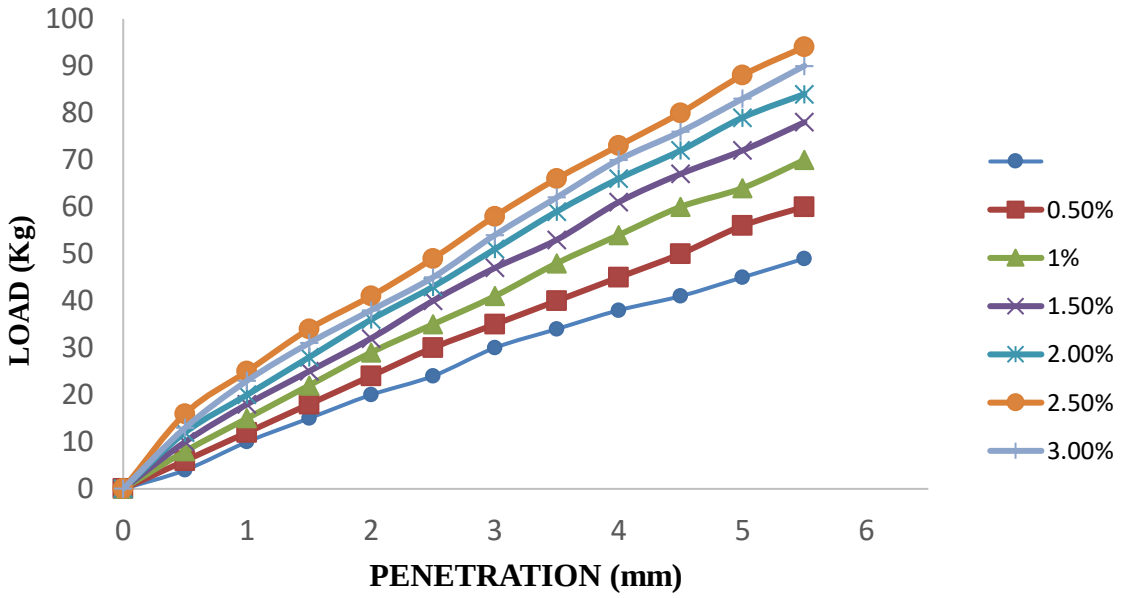

Figure 3: Soaked CBR of soil at different dosages of chemical

Unconfined compressive strength (UCS)
UCS test results of soil with calcium chloride (24 Hours)

Table 5: UCS results

Sr no.	Strain	Stress (kPa) soil	Stress (kPa) soil+0.5%	Stress (kPa) soil+1.0%	Stress (kPa) soil+1.5%	Stress (kPa) soil+2.0%	Stress (kPa) soil+2.5%	Stress (kPa) soil+3%
1.	0	0	0	0	0	0	0	0
2.	0.05	4.32	6.23	7.34	9.45	11.56	15.67	13.07
3.	0.10	9.56	11.65	13.76	15.87	17.78	24.89	21.71
4.	0.15	14.22	16.35	19.46	23.57	26.68	33.79	30.9
5.	0.21	19.52	21.25	26.36	28.47	34.58	48.60	43.98
6.	0.26	23.58	26.85	33.96	35.67	44.77	65.48	55.03
7.	0.31	28.63	31.63	38.47	45.58	52.69	78.40	70.06
8.	0.36	33.25	37.52	44.63	55.68	67.94	97.04	92.29
9.	0.42	38.64	45.98	57.87	75.74	86.94	95.02	87.34
10.	0.47	43.89	57.54	65.63	72.97	79.08	90.45	82.02

11.	0.52	49.45	54.76	62.87	69.74	76.04	87.03	80.02
12.	0.57	44.67	50.44	59.07	66.08	72.06	84.02	

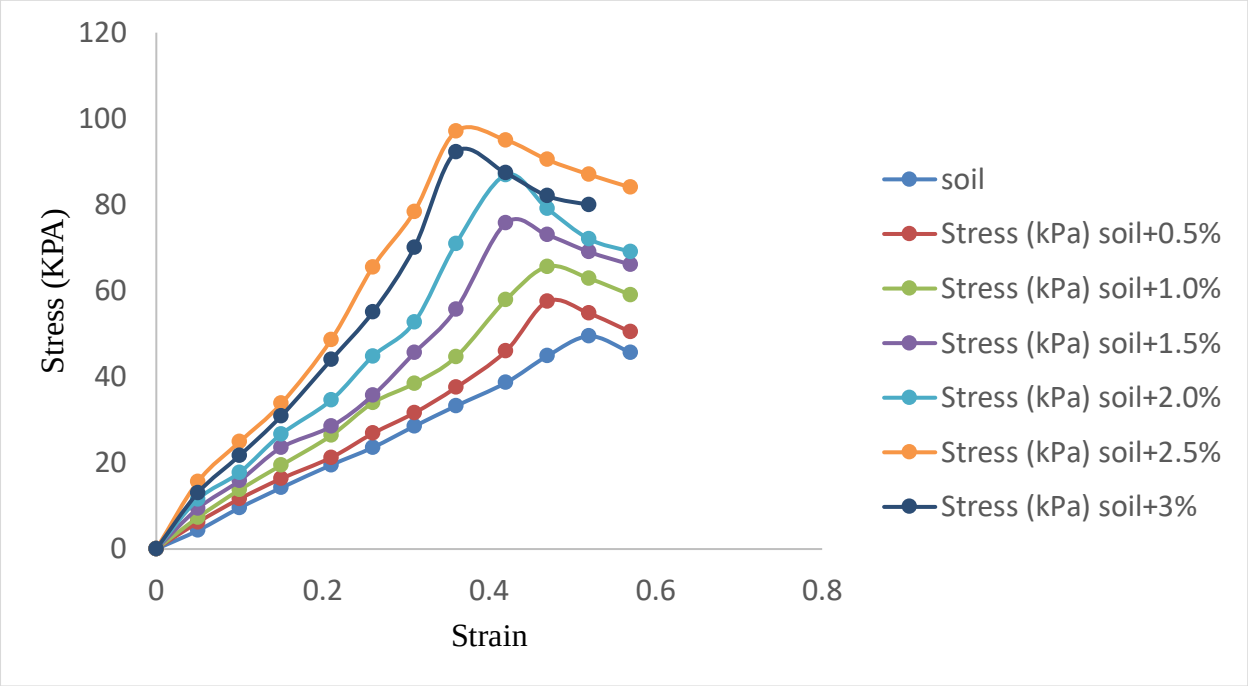

Figure 4: Stress v/s Strain for 24 hours of curing

UCS results of soil with calcium chloride (7 days)-

Table 6: UCS values at 7 days of curing

Sr no.	Strain	Stress (kPa) soil	Stress (kPa) soil+0.5%	Stress (kPa) soil+1.0%	Stress (kPa) soil+1.5%	Stress (kPa) soil+2.0%	Stress (kPa) soil+2.5%	Stress (kPa) soil+3%
1.	0	0	0	0	0	0	0	0
2.	0.05	4.32	8.43	10.54	12.65	17.27	19.70	18.07
3.	0.10	9.56	15.67	17.87	19.87	26.03	35.94	28.19
4.	0.15	14.22	20.64	25.57	29.08	41.70	50.09	42.98
5.	0.21	19.52	28.63	30.74	36.85	57.07	61.71	60.71
6.	0.26	23.58	34.69	37.76	45.09	69.09	75.09	72.06
7.	0.31	28.63	39.74	42.85	59.58	81.09	98.71	83.03

8.	0.36	33.25	47.36	51.47	65.58	91.09	114.06	94.29
9.	0.42	38.64	52.75	60.86	75.9	109.49	109.94	85.03
10.	0.47	43.89	58.75	76.49	90.68	97.07	102.29	
11.	0.52	45.45	65.36	73.79	86.69	91.07		
12.	0.57	49.45	62.34	70.47	80.05	88.07		
13.	0.62	44.45						

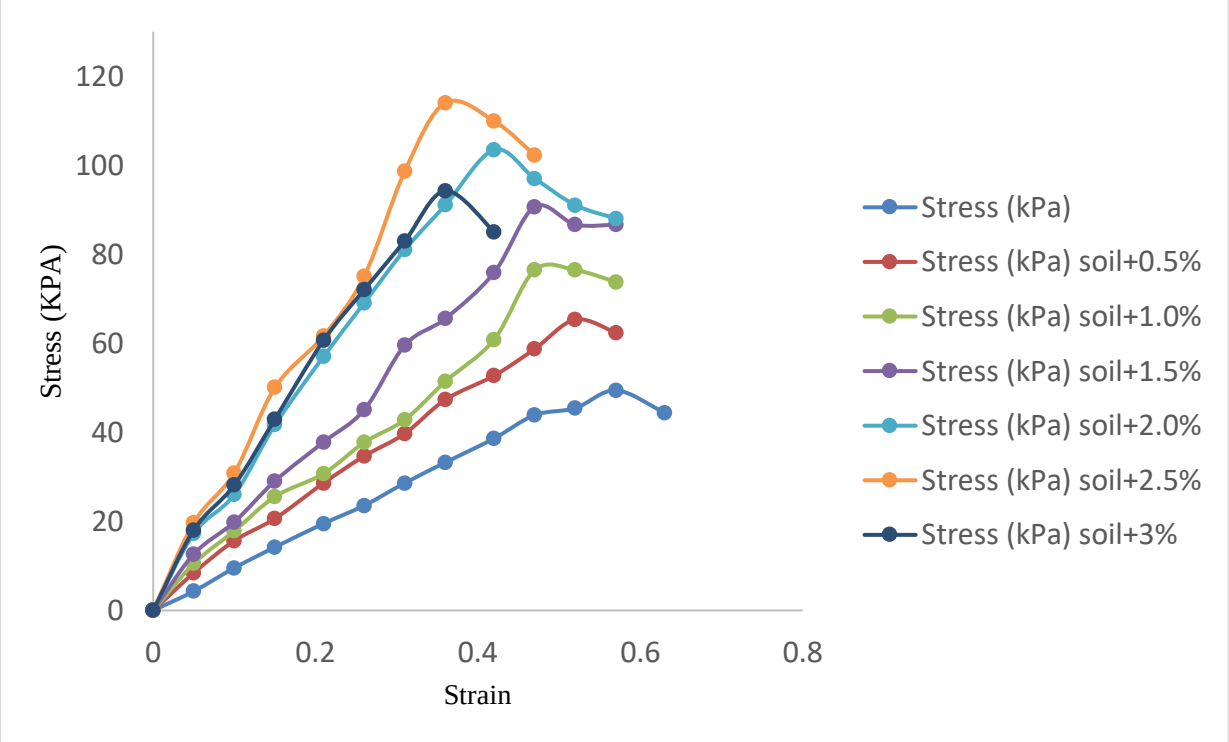

Figure 5: Stress v/s Strain at 7 days of curing

CONCLUSIONS

1. Maximum dry density of soil increases while optimum moisture content decreases with increment in the dosage of calcium chloride up to 2.5% and further decreases. MDD increases up to 9.02% that of virgin soil.
2. Liquid limit and plastic limit of soil decreases with the addition of calcium chloride. Liquid limit of soil decreases up to 8.3% as compared to virgin soil. Plasticity index decreases up to 10% as compared to virgin soil.
3. With the addition of calcium chloride CBR (unsoaked) value of soil is maximum at 2.5%. The CBR value increases up to 98% as compared to virgin soil.

4. CBR (soaked/unsoaked) value of soil increases with the increment in calcium chloride up to 2.5% and decreases with further addition of dosage. The CBR value increases up to 200% as compared to virgin soil.
5. It was studied that UCS samples of curing period 24 hours and 7 days shows increasing trend in the strength up to 2.5% of calcium chloride while further addition of chemical cause decrement in value. UCS value of 24 hours of curing increases up to 50% as compared to virgin soil. UCS value of 7 days of curing increases up to 67% as compared to virgin soil.

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