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GEOTECHNICAL SITE INVESTIGATION FOR A PROPOSED CONSTRUCTION OF DOUBLE-STOREY HOUSES IN COLLAPSIBLE SOILS NEAR JHELUM AREA IN KASHMIR

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ABSTRACT

Geo-Technical Engineering plays a vital role in any construction projects like in the construction of bridge, roads, buildings, development of hydro power projects, foundation of massive structures like big chimney and transmission towers. The main purpose of the investigation is to get an idea related to the site where the structure is to be built. This not only saves the design and construction time but also may be considered as the main source of information for the proper planning, safe and sound, economical design and proper execution. The geo-technical investigation also gives us ideas about the Sub-surface condition of the site where the construction is to be proposed. Geo-technical investigations can be considered as an essential part for the design of structures and for the planning the construction techniques. Geo-technical investigations can be carried out for determination of the natural profile of soil deposits at the site, withdrawing the soil samples at the site and then determining engineering and index properties of that soil. Sampling of soil can be approached in two ways: - It can be laboratory test or it can be in situ testing of the soil. The study of collapsible soils was started as early as 1820s, but due to the inadequate knowledge on the nomenclature of soil collapse, the researchers cannot predict the full understanding of collapse phenomenon. Also, due to the variety in types and chemical composition of soils has amplified this problem. Therefore, this dissertation will provide the advance and point to point knowledge on collapsible soil which will help the researchers to understand the behavior of collapsible soil in better ways. For this dissertation work to be carried out smoothly and to predict the soil collapse at the proposed site (Sangam site) it was necessary to go for the laboratory testing as this part focuses the prime concern and objective of this dissertation. The sampling was done at Sangam were a multi storied building was proposed for the construction. This site being very close to the river Jehlum has various serious impacts for being the collapsible soil due to the presence of water in its vicinity. Various geotechnical experiments were performed for the determination of Index and engineering properties of collapsible soil. Moreover, Soil structure was also studied and a correlation was developed between the void ration, loading on the soil along with various parameters like dry density, Moisture content and porosity.

As these problematic soils gave a challenge for the geotechnical engineers regarding the construction on this type of soil. Furthermore, this problematic soil covers almost 10% of the earth's land. In order to mitigate this problem, understanding the collapse mechanism is of utmost importance because it saves us the maintenance cost and even sometimes the human lives. Therefore, in this research a key aspect will be highlighted which directly or indirectly affects the collapse by analyzing the various properties of collapsible soil. The outcome of this dissertation is to have a proper understanding for the collapse phenomenon and the factors which affects it. To achieve the goal of this dissertation and to summarize the result the index property of soil was studied, remedial measures were given to the collapse soil by using magnesium chloride as a green stabilizer and the chemistry of collapse potential were studied by Consolidmeter. A series of the tests were performed on the collapsible soil on the various factors such as dry density, water content and surcharge pressure. Also, Consolidmeter test were performed to determine the collapse potential. Experimental results though obtained proves that collapsibility of soil is directly proportional to the various properties of soil such as dry density, water content and total load applied on collapsible soil. Furthermore, the collapse potential was studied in depth by taking a green stabilizer in the form of magnesium chloride to determine the remediation of collapse

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potential. Furthermore, magnesium chloride acts as de- icing agent which controls the collapsibility of the soil. It was also observed that magnesium chloride improves the mechanical behavior of collapsible soil.

I. INTRODUCTION

Geo-Technical Engineering plays a vital role in any construction projects like in the construction of bridge, roads, buildings, development of hydro power projects, foundation of massive structures like big chimney and transmission towers. The main purpose of the investigation is to get an idea related to the site where the structure is to be built. This not only saves the design and construction time but also may be considered as the main source of information for the proper planning, safe and sound, economical design and proper execution. The geo-technical investigation also gives us ideas about the Sub-surface condition of the site were the construction is to be proposed. Geo-technical investigations can be considered as an essential part for the design of structures and for the planning the construction techniques. Geo-technical investigations can be carried out for determination of the natural profile of soil deposits at the site, withdrawing the soil samples at the site and then determining engineering and index properties of that soil. Sampling of soil can be approached in two ways: - It can be laboratory test or it can be in situ testing of the soil. The main purpose of the Geo-technical investigation is to determine the suitable type of foundation for any structure, to determine its bearing capacity and depth of foundation, geo-technical investigation will help us in determining the settlements, it will help us to evaluate and adopt the suitable construction technique. With the help of Geo-technical investigation various problems related to the foundation will be solved up to a potential limit. Overall soil stability of soil as a construction material for the construction of any structure, various remedial measures which can encounter during the construction stage can be solved with the help of geo-technical investigation.

This study deals with the various studies put forward by the various researchers and geo-technical engineers related to the various site investigations and sub-surface exploration for the determination of information of surface as well as sub-surface conditions. A Geo-technical engineer is the person who is responsible for carrying out the extensive study of soil as the proposed site for the construction of any structure. Various researches and papers were studied extensively to find out the conclusions of the studies carried out by those researchers.

Collapsible soils may be formed due to geological hazard in civil engineering projects. As far as construction is concerned, this type of soil always poses a challenge for engineers as well as geotechnical experts due to non-availability of the knowledge on this soil. This chapter in this dissertation work provides brief information about collapsible soil and the interests for choosing this research topic. This chapter also briefs us the four objectives that were notified and defined to have the through research about the collapsible soil.

Rapid increase in population has resulted in the land occupancy and tremendously increased the construction techniques on those problematic soils. Due to this rapid increase in population it is considered to be the important aspect for geotechnical engineers to have in depth knowledge to deal with such type of soil, including collapsible soils. As far as collapsible soils are concerned, they have the tendency to withstand good number of loads in an unsaturated condition, the settlements may it be equal or unequal settlement associated with the induction of water into this system may some sometimes lead to extensive repairs. Due to increase in water content, unforeseen reduction in volume may prove as one of the most costly and complicated geological hazards in geo-technical engineering.

Construction failures which are associated with collapsible soils may led to enormous maintenance costs. Development of cracks associated in and near the vicinity of sangam and along the Jammu Srinagar highway in the buildings and there foundation failures are some of the examples caused by unequal settlement of collapsible soil. The main concern is not associated only to the failures but the prime concern is the maintenance and operational costs. Therefore, it becomes and important parameter to identify, to characterise and to predict the collapse potential of the soil as well as finding the new solutions to mitigate the complex problems which are directly related to collapsible soils, and may have crucial issues for geotechnical engineers.

The study of collapsible soils was started as early as 1820s, but due to the inadequate knowledge on the nomenclature of soil collapse, the researchers cannot predict the full understanding of collapse phenomenon. Also, due to the variety in types and chemical composition of soils has amplified this problem. Therefore, this

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dissertation will provide the advance and point to point knowledge on collapsible soil which will help the researchers to understand the behaviour of collapsible soil in better ways.

The main aim of this research is to develop a proper concept and good understanding of the behavior of collapsible soils to estimate the collapse settlement and to minimize the geotechnical hazards associated with this type of problematic soil. In order to fulfill this goal following objectives should met: -

1. To characterize the natural collapsible soil so that a proper correlation should be developed for the better understanding of the micro mechanism of collapse.
2. To identify the influence of core water pH level on the collapse potential.
3. To understand the effect of magnesium chloride as a green stabilizer for controlling the collapse potential.

Above objects are accomplished by the Implementation of the following primary tasks: -

1. To study and to develop the proper mechanism of collapsible soil by determining the various factors which are directly or indirectly responsible for the collapse. This parameter was achieved by obtaining the effects of various factors such as dry density, moisture content and soil pressure on the soil by keeping other factors constant.
2. To study the parametric mechanism of collapsible soil by analyzing the particle size distribution which came under pore pressure and correlating its various parameters with soil suction power under various experimental conditions.
3. To study the feasibility of the performance and effectiveness of green soil stabilizer like magnesium chloride for the control of soil collapse. Various tests were performed on this parameter by taking various soil samples with different percentages of magnesium chloride solution.

For this dissertation work to be carried out smoothly and to predict the soil collapse at the proposed site (Sangam site) it was necessary to go for the laboratory testing as this part focuses the prime concern and objective of this dissertation. The sampling was done at Sangam were a multi storied building was proposed for the construction. This site being very close to the river Jehlum has various serious impacts for being the collapsible soil due to the presence of water in its vicinity. Various geotechnical experiments were performed for the determination of Index and engineering properties of collapsible soil. Moreover, Soil structure was also studied and a correlation was developed between the void ration, loading on the soil along with various parameters like dry density, Moisture content and porosity.

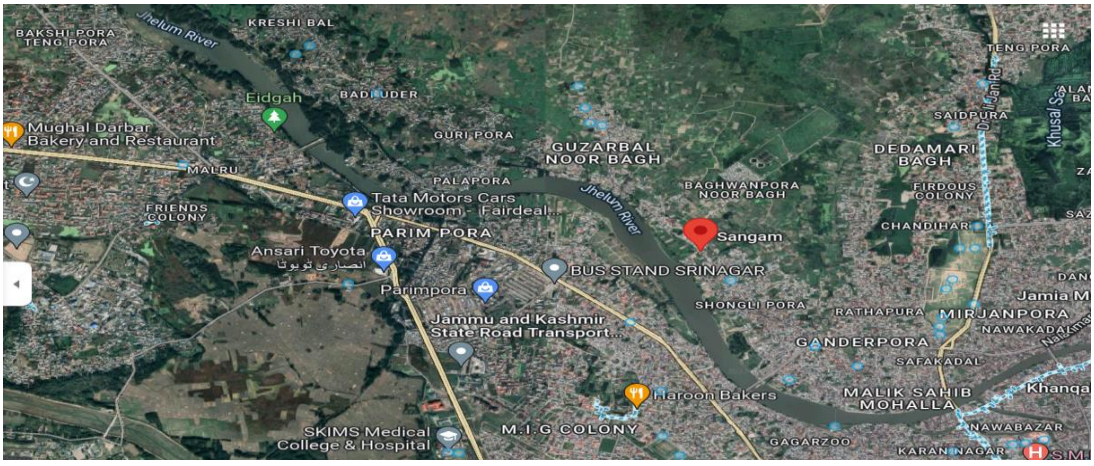

Figure: Study Area Location

II. METHODOLOGY

Experiments play an important role for carrying out the dissertation in order to validate the research gaps. Few tests which were carried out in this dissertation are listed as: -

A). Preliminary Test

i. Sieve Analysis

ii. Pycnometer Test

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iii. Liquid Limit.

iv. Plastic Limits.

The above tests were experimented in order to determine the index properties of soil.

B). Collapse Test

This test on soil is used to determine the behavior of the soil and to measure and get the adequate knowledge about the collapsibility. For this consolidation parameters were used to determine the collapse potential

Sample Collection

For this dissertation work to be carried out smoothly and to predict the soil collapse at the proposed site (Sangam site) it was necessary to go for the laboratory testing as this part focuses the prime concern and objective of this dissertation. The sampling was done at Sangam were a multi storied building was proposed for the construction. This site being very close to the river Jehlum has various serious impacts for being the collapsible soil due to the presence of water in its vicinity. Various geotechnical experiments were performed for the determination of Index and engineering properties of collapsible soil. Moreover, Soil structure was also studied and a correlation was developed between the void ration, loading on the soil along with various parameters like dry density, Moisture content and porosity.

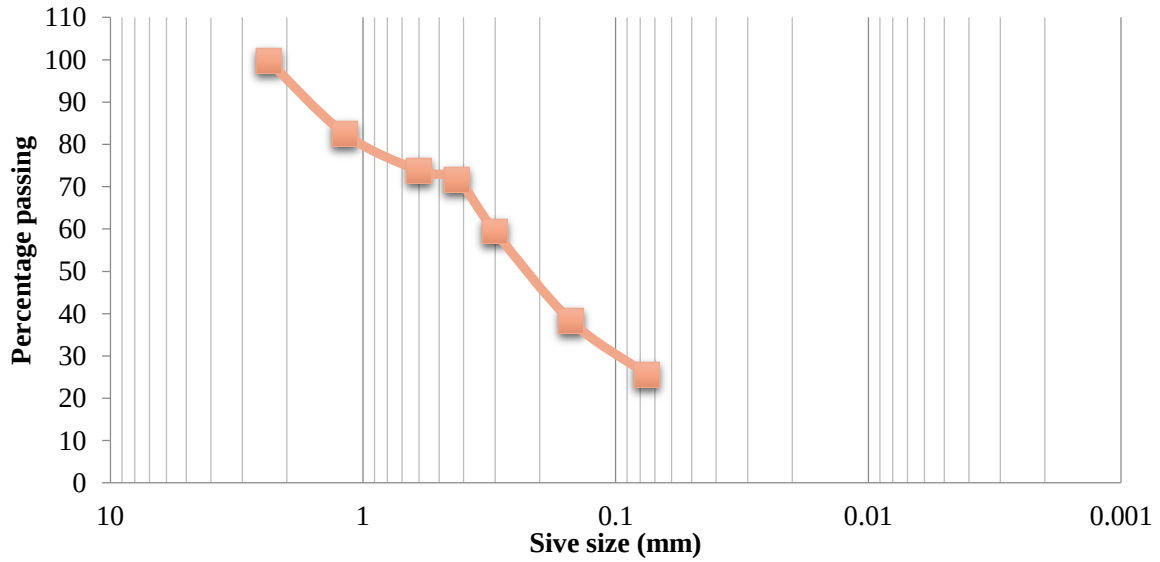
In order to observe and to analyse the soil behavior at Sangam site the soil excavated for the foundation purpose was collected. This soil was transported to the laboratory to determine various index properties.

III. RESULTS

Sieve Analysis

Data of Sieve Analysis

S. No	Sieve (mm)	Weight of sample retained on sieve	Cumulative weight retaining on sieve	Percentage of soil retained on sieve	Percentage of soil passed on sieve
1	2.360	2.34	2.34	0.26	99.74
2	1.180	155.32	157.66	17.52	82.48
3	0.600	78.32	235.98	26.22	73.78
4	0.425	19.34	255.32	28.37	71.63
5	0.300	110.34	365.66	40.63	59.37
6	0.150	190.16	555.82	61.76	38.24
7	0.075	113.90	669.72	74.41	25.59
8	Pan	130.28	800.00	100.00	0.00



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Particle size distribution curve

Specific Gravity Test

Specific Gravity of parent soil

Container Number	I
Weight of empty pycnometer (M_1)	37.15
Mass of pycnometer + mass of dry soil (M_2)	63.28
Mass of pycnometer + soil + distilled water (M_3)	153.88
Mass of pycnometer + fill with water only (M_4)	137.28
Specific gravity G	2.64

Calculations

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$= \frac{63.28-37.15}{(63.28-37.15)-(153.88-137.28)}$

$= \frac{26.13}{26.13-16.60}$

$= \frac{26.13}{9.53}$

= 2.74

Therefore, specific gravity of parent soil = 2.74

Liquid Limit and Plastic Limit Test

Liquid Limit and Plastic Limit Test

Determination Number	1	2	3	4
No. of blows	40	36	20	10
Sample No	I	II	III	IV
Wt. of container W_1 (g)	10.86	10.82	11.188	11.289
Wt. of container + wet soil W_2 (g)	48.26	55.42	48.688	43.589
Wt. of container + dry soil W_3 (g)	37.16	41.12	35.488	33.689
Wt. of moisture content (W_2-W_3) (g)	11.1	14.3	13.2	9.9
Wt. of dry soil (W_3-W_1) g	26.3	30.3	24.3	22.4
Water content = (W_2-W_3/ W_3-W_1) x 100	42.21%	47.19%	54.32%	44.20%

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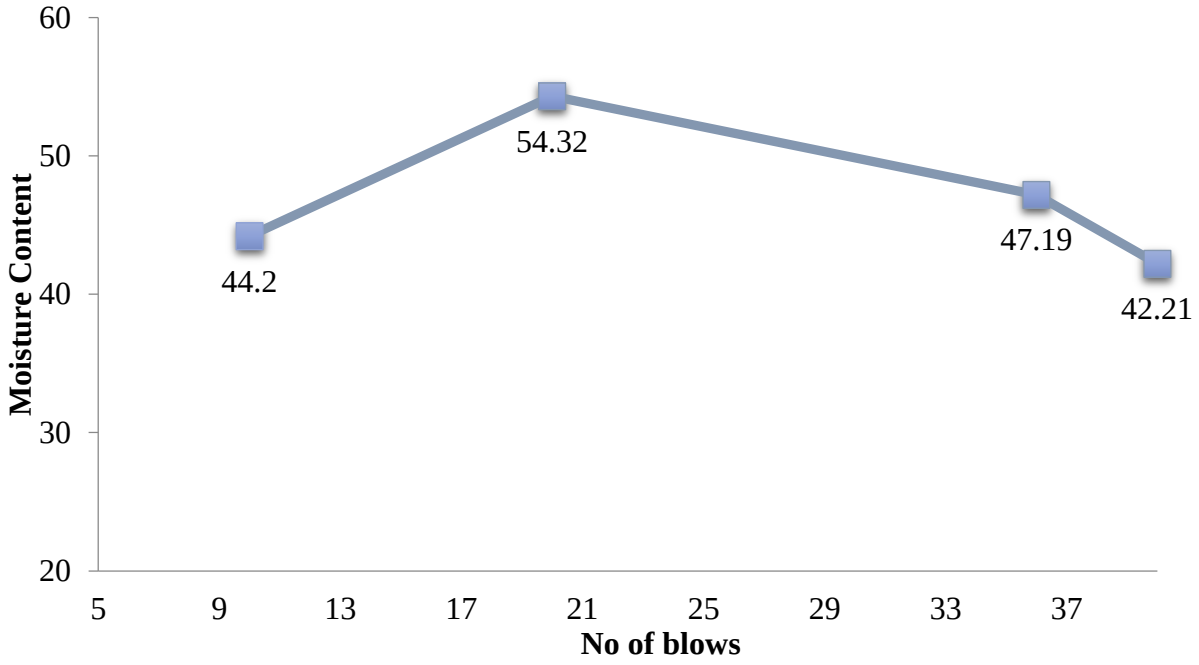

Figure: Liquid Limit

Liquid Limit, Plastic Limit and Plasticity Index

S. No	Parameter	Value
1	Liquid Limit	52.09
2	Plastic Limit	29.14
3	Plasticity Index	22.95

Consolidation Test Results

Consolidation Test Results

Dry Density (Kg/m^3)	Moisture Content (%)	Inundation Pressure (Kpa)
1310	7.7	100
1335	7.7	100
1360	7.7	100
1385	7.7	100
1335	4.9	100
1335	8.9	100
1335	7.7	50
1335	7.7	200

California Bearing Ratio Test Results

The California Bearing Ratio Test results of virgin soil as well as of soil samples mixed with varying percentages of Magnesium Chloride are tabulated and shown in Figure 4

CBR Test Results for Virgin Soil

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S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	15.854
3	1	24.404
4	1.5	30.704
5	2	38.804
6	2.5	44.654
7	4	56.354
8	5	63.104
9	7.5	81.554
10	10	94.154
11	12.5	107.254

CBR Test Results for Soil Mixed With 10g Magnesium Chloride

S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	15.854
3	1	28.904
4	1.5	33.404
5	2	38.354
6	2.5	54.104
7	4	61.754
8	5	73.004
9	7.5	100.904
10	10	119.354
11	12.5	142.354

CBR Test Results for Soil Mixed With 15g Magnesium Chloride

S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	11.354
3	1	26.204
4	1.5	29.354
5	2	40.604
6	2.5	50.954
7	4	62.654
8	5	71.654
9	7.5	97.754
10	10	117.554
11	12.5	135.154

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CBR Test Results for Soil Mixed With 20g Magnesium Chloride

S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	28.004
3	1	35.654
4	1.5	41.954
5	2	50.504
6	2.5	56.354
7	4	73.454
8	5	82.904
9	7.5	100.904
10	10	114.854
11	12.5	120.754

CBR Test Results for Soil Mixed With 25g Magnesium Chloride

S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	22.604
3	1	36.554
4	1.5	43.754
5	2	50.954
6	2.5	58.154
7	4	69.404
8	5	81.554
9	7.5	93.254
10	10	105.454
11	12.5	118.454

CBR Test Results for Soil Mixed With 30g Magnesium Chloride

S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	31.604
3	1	40.154
4	1.5	46.904
5	2	54.554
6	2.5	60.854
7	4	79.304
8	5	90.104
9	7.5	128.854
10	10	148.154

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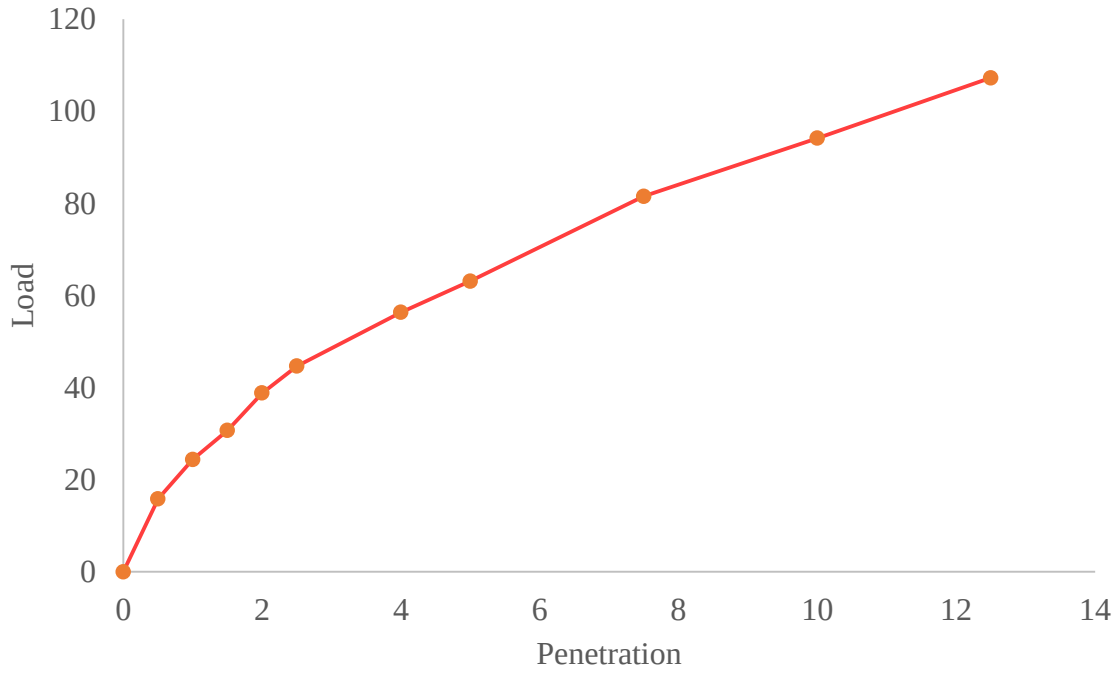
11	12.5	172.054

CBR Test Results for Soil Mixed With 35g Magnesium Chloride

S. No	Penetration (mm)	Load (kg)
1	0	0
2	0.5	19.454
3	1	32.054
4	1.5	41.054
5	2	50.054
6	2.5	59.054
7	4	75.704
8	5	86.054
9	7.5	101.354
10	10	114.454
11	12.5	131.554



CBR Test Results for Virgin Soil

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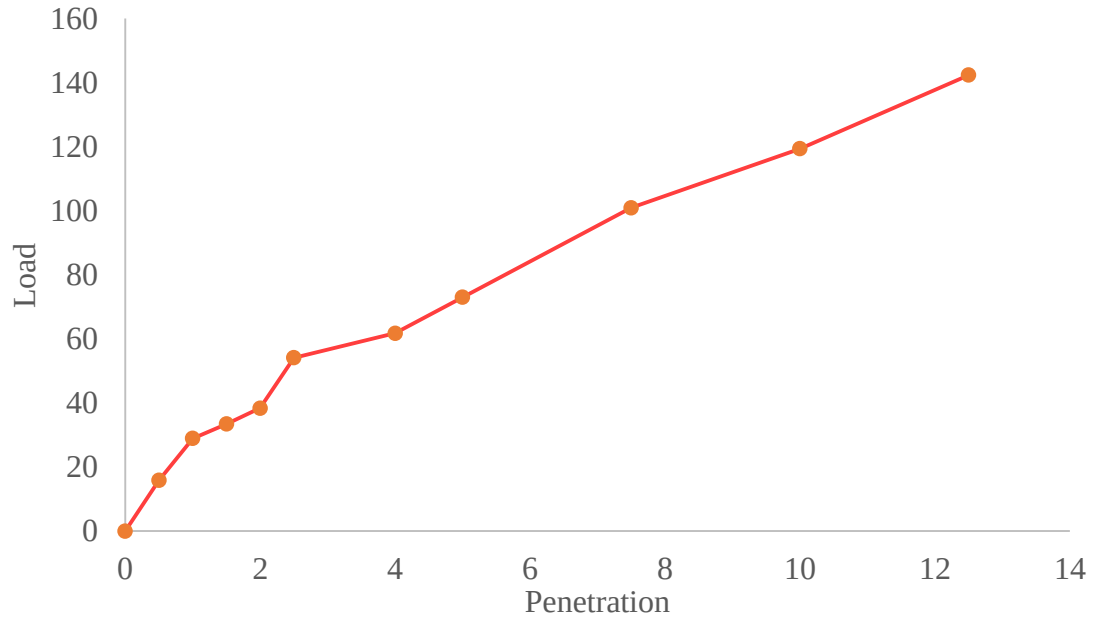
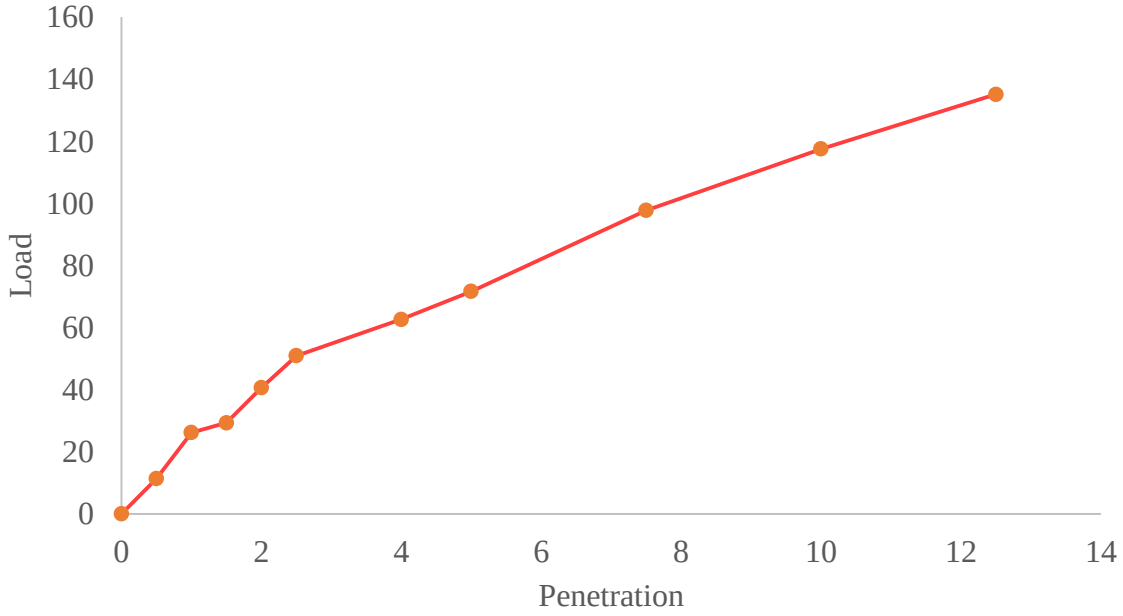


CBR Test Results for Soil Mixed With 10g Magnesium Chloride



CBR Test Results for Soil Mixed With 15g Magnesium Chloride

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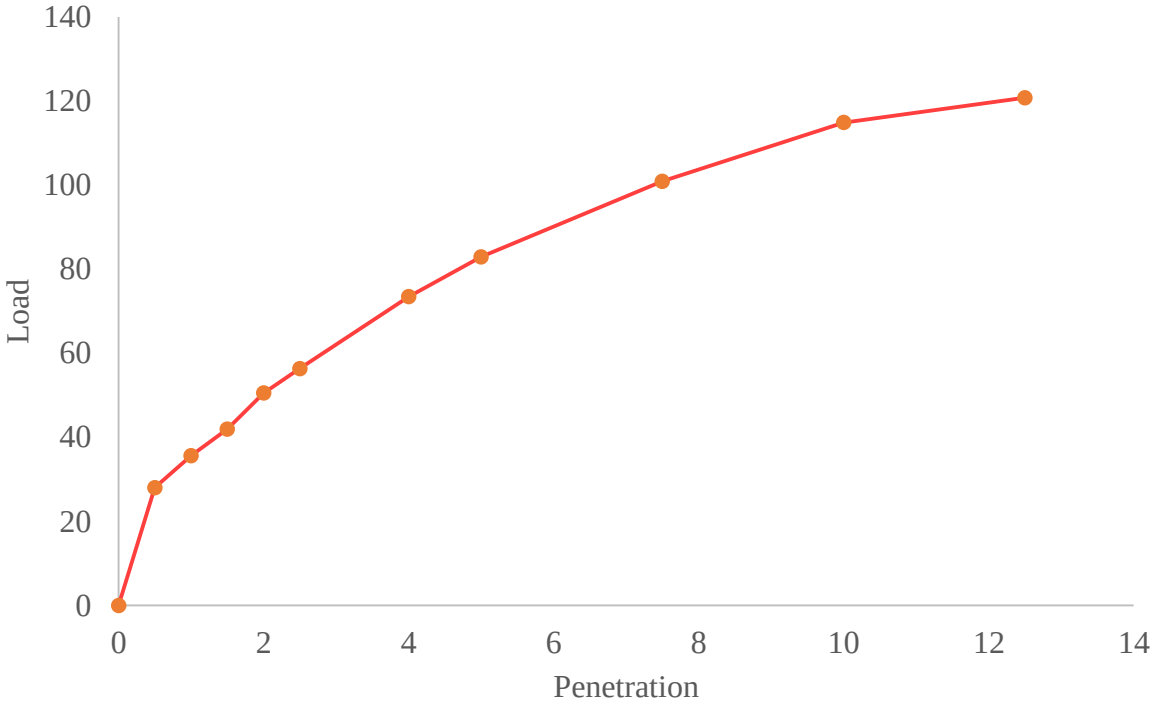
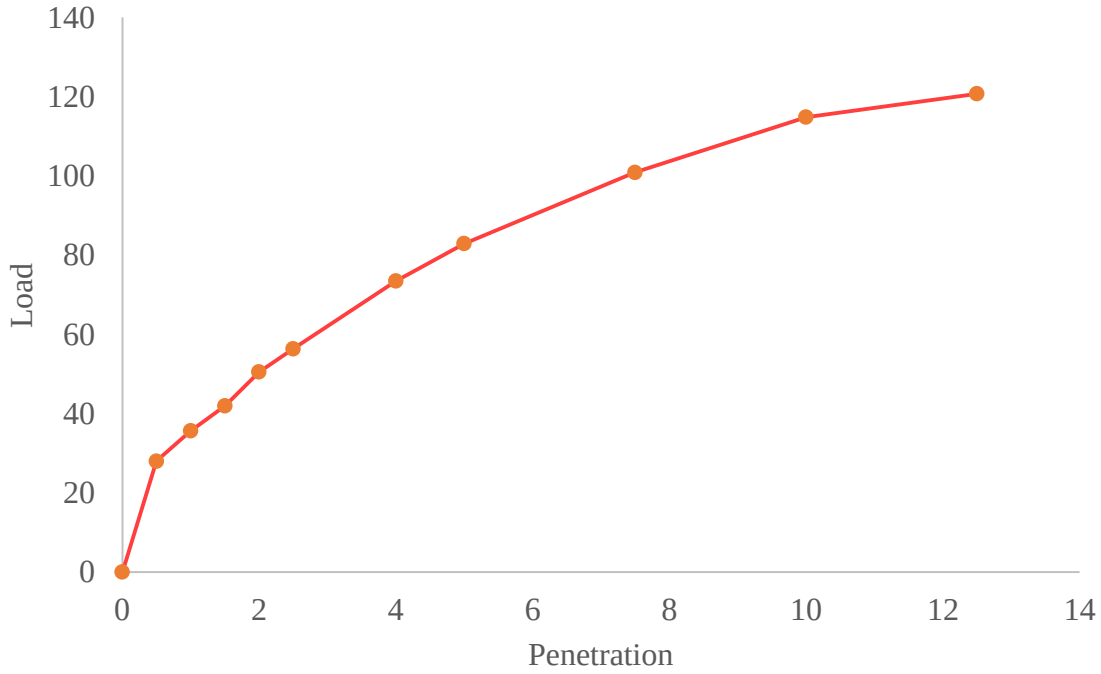


CBR Test Results for Soil Mixed With 20g Magnesium Chloride



CBR Test Results for Soil Mixed With 25g Magnesium Chloride

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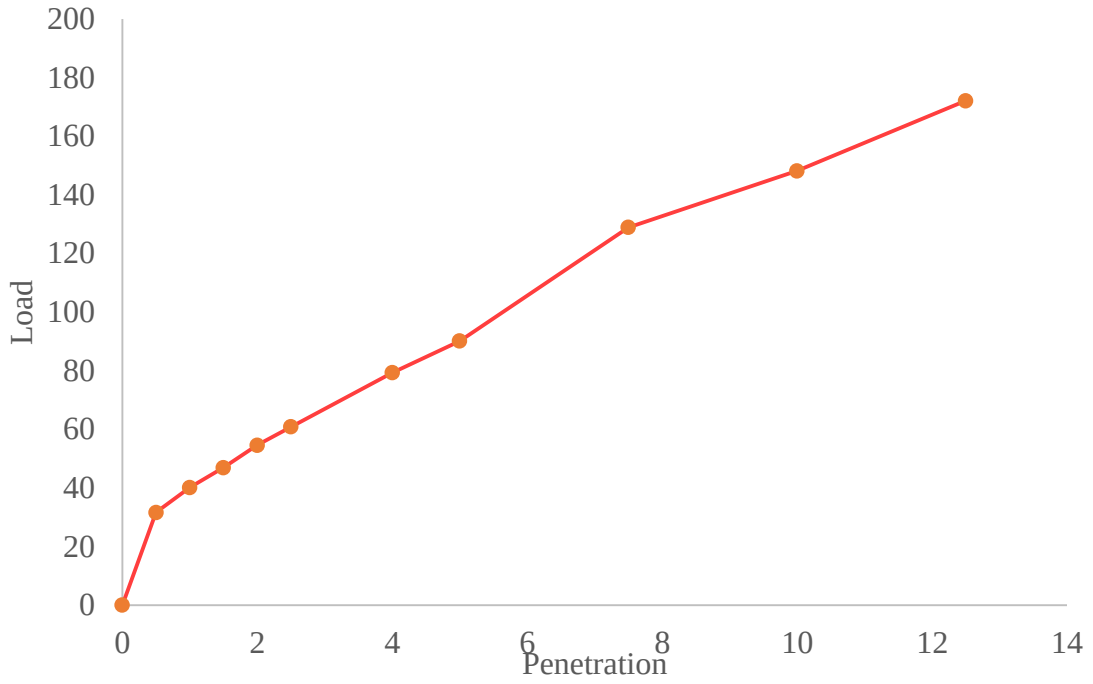
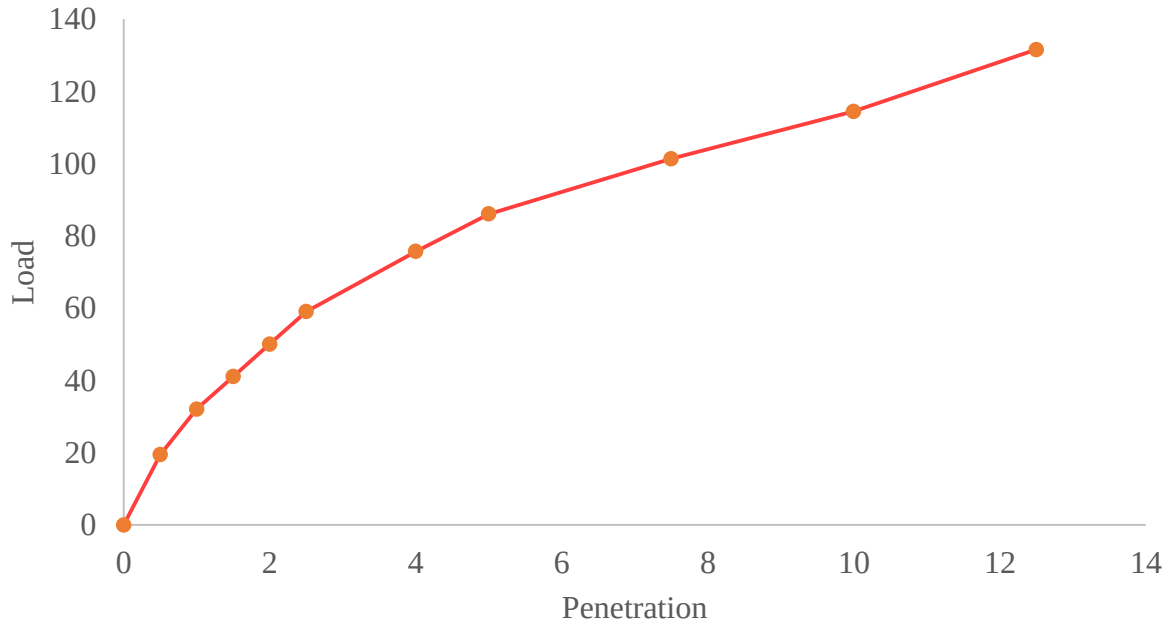


CBR Test Results for Soil Mixed With 30g Magnesium Chloride



CBR Test Results for Soil Mixed With 35g Magnesium Chloride

IV. CONCLUSION

Collapsible soil as we know are the problematic soils which occurs due to the geo-chemical hazards which directly contributes to the high cost of maintenance. As these problematic soils gave a challenge for the geotechnical engineers regarding the construction on this type of soil. Furthermore, this problematic soil covers almost 10% of the earth's land. In order to mitigate this problem, understanding the collapse mechanism is of utmost importance because it saves us the maintenance cost and even sometimes the human lives. Therefore, in this research a key aspect will be highlighted which directly or indirectly affects the collapse by analyzing the various properties of collapsible soil. The outcome of this dissertation is to have a proper understanding for the collapse phenomenon and the factors which affects it. To achieve the goal of this dissertation and to summarize the result the index property of soil was studied, remedial measures were given to the collapse soil by using

magnesium chloride as a green stabilizer and the chemistry of collapse potential were studied by Consolidmeter. Results though obtained were analyzed as conclusion drawn are summarized below: -

- A series of the tests were performed on the collapsible soil on the various factors such as dry density, water content and surcharge pressure.
- Also, Consolidmeter test were performed to determine the collapse potential.

Experimental results though obtained proves that collapsibility of soil is directly proportional to the various properties of soil such as dry density, water content and total load applied on collapsible soil.

- Furthermore, the collapse potential was studied in depth by taking a green stabilizer in the form of magnesium chloride to determine the remediation of collapse potential.
- Furthermore, magnesium chloride acts as de- icing agent which controls the collapsibility of the soil.
- It was also observed that magnesium chloride improves the mechanical behavior of collapsible soil.

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