EFFECT OF GYPSUM ON ATTERBERG LIMITS AND COMPACTION CHARACTERISTICS OF SOIL

A thesis submitted in partial fulfilment of requirements

For the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

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Abstract:

There are several places in the world particularly middle East Asia and Africa has problem of gypsum contaminated soil known as gypsiferous soil. Gypsiferous soils cover approximately 100 million hectors in the world. Gypsum not only dissolve in presence of water it also changes geotechnical properties of soil. In the current study effect of gypsum on Atterberg limits and compaction character tics of soil was studied. Different percentage of gypsum was added with a soil from Rourkela to simulate the conditions of Gypsiferous soil. Laboratory test were conducted to determine effect of gupsum content on liquid limit, plastic limit and compaction characteristics of soil. It was noted that with increase in gypsum content liquid limit and plastic limit of soil decreased. The Maximum Dry Density (MDD) was noted to decrease continuously on increasing gypsum content. Although, some deviation were noted, in general a trend of increasing Optimum Moisture Content (OMC) was noted with increase in gypsum content.

CERTIFICATE

This is to certify that project entitled "**Effect of gypsum on Atterberg limits and compaction characteristics of soil"** submitted by **Ambuj Shukla** in partial fulfilment of the requirements for the award of **Bachelor of Technology** Degree in **Civil Engineering** at **National Institute of Technology, Rourkela** is an authentic work carried out by him under my personal supervision and guidance. To the best of my insight the matter exemplified in this project thesis has not been submitted in any College/Institute for granting degree or recognition.

Dr R Bag

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AMBUJ SHUKLA

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CHAPTER 1

INTRODUCTION

There are several places in the world particularly middle East Asia and Africa has problem of gypsum contaminated soil known as gypsiferous soil.

The origin of sulphate ions in the soil solution is in some circumstances due to the presence of sulphur-rich minerals such as pyrite in the parent material. By weathering and oxidation, the sulphur in these minerals is transformed into sulphuric acid which in calcareous soils reacts with $CaCO_3$ to form gypsum.

On irrigated land, leaching of saline soils containing sulphate and calcium in the soil solution leads in some circumstances to the precipitation and accumulation of gypsum in the subsurface horizon. The formation of gypsum may result from replacement of NaCl by $CaSO_4$ when the irrigation water contains a substantial amount of calcium and sulphate. But it could be also a result of a partial leaching of salts from the soil because NaCl is much more soluble than $CaSO_4$. It has been observed in the Euphrates Basin, that gypsum is recrystallized and redistributed in the soil profile after leaching of other, more soluble, salts.

Gypsiferous soils cover approximately 100 million hectors in the world (Verheye and Boyagiev, 1997). Gypsum not only dissolve in presence of water it also changes geotechnical properties of soil. Therefore detailed investigation is required to find out the change in geotechnical properties of gypsum contaminated soil.

In soils with a recent accumulation of gypsum, the salt-affected horizon overlies the gypsic horizon. In the case of old or residual gypsum, the accumulation of soluble salts occurs either in the gypsic horizon or at lower depths.

CHAPTER 2

LITERATURE REVIEW:

There is a limited number of literature and studies available in the present context of research. The valuable works are listed below.

Petrukhin and Arakelyan (1984) examined the character of variation in the porosity and strength of the soils as a function of initial gypsum content and found out that in the sandy loam, the porosity increases with increasing initial gypsum content. More brittle crystals, the mutual coalescence of which gives rise to the appearance of low cohesion are found with increasing gypsum content.

Verheye and Boyadgiev (1997) focused on gypsum accumulation forms as diagnostic criteria for a rapid soil suitability appraisal in the field. Pseudo mycelia, gypsum spots, powdery coatings and other localized *in situ* precipitations usually indicate soils with less than 15% gypsum. Depending on their intensity and depth of occurrence in the root zone, they define a soil environment which is suitable for semi-sensitive and semi-tolerant crops.

Razouki et al. (2013) studied the hydro-mechanical behaviour of partially saturated sandy soil. They observed a significant drop in the cohesion and angle of internal friction, with an increase in soaking period for a chosen compactive effort.

Ahmed (2013) studied the hydro-mechanical behaviour of partially saturated sandy soil. With an increase in gypsum content optimum moisture content and maximum dry density decreased. Decrease in friction angle and effective stress parameter were also noted with increase in gypsum content.

Objective: Based on the above literature review it was observed that most of the previous researchers have reported the influence of gypsum content on geotechnical properties of soil using soil from Middle East region. There is no work reported on Indian soil showing the effect of gypsum content on geotechnical properties of soil. Therefore, main objective of the current study was to study effect of gypsum content on Liquid limit, plastic limit and compaction characteristics of a low plastic soil from Rourkela.

CHAPTER 3

MATERIAL AND METHODS

Low plastic soil from Rourkela was used to for this study. Liquid limit, plastic limit and specific gravity tests were carried out using distilled water following Indian Standard (IS) method.

Atterberg Limits –Liquid limit and Plastic limit tests

Atterberg limits are defined as the water content corresponding to different behaviour conditions of fine-grained soil (silts and clays). The four states of consistency in Atterberg limits are liquid, plastic, semisolid and solid. The dividing line between liquid and plastic states is the liquid limit; the dividing line between plastic and semisolid states is the shrinkage limit. If a soil in the liquid state is gradually dried out, it wills past through the liquid limit, plastic state, plastic limit, semisolid state and shrinkage limit and reach the solid stage. The liquid, plastic and shrinkage limits are therefore quantified in terms of the water content at which a soil changes from the liquid to the plastic state. The difference between the liquid limit and plastic limit is the *plasticity index*. Because the liquid limit and plastic limit are the two most commonly used Atterberg limits, the following discussion is limited to the test procedures and calculation for these two laboratory tests.

The liquid limit is that moisture content at which a soil changes from the liquid state to the plastic state. It along with the plastic limit provides a means of soil classification as well as being useful in determining other soil properties.

Plastic limit is the dividing line between the plastic and semisolid states. From a physical standpoint, it is the water content at which the soil will begin to crumble when rolled in small threads. In the current study liquid limit of soil was determined by Casargrande apparatus.

SPECIFIC GRAVITY TEST

Specific gravity of soil solids was determined using a pycnometer. Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature. Indian Standard (IS) test procedure was followed to determine the Specific Gravity of Soil Solids by Water Pycnometer. The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil.

The results obtained by conducting above tests on low plastic soil from Rourkela are presented in Table 3.1

Table 3.1: Properties of soil used in this study

Properties	value
Liquid limit (%)	30
Plastic limit (%)	16.5
Specific gravity	2.73

STANDARD PROCTOR COMPACTION TEST

For construction of highways, airports, and other structures, it is often necessary to compact soil to improve its strength. Proctor (1933) developed a laboratory compaction test procedure to determine the maximum dry unit weight of compaction of soils, which can be used for specification of field compaction. This test is referred to as the Standard Proctor Compaction Test. In the current study standard Proctor compaction test was carried out for various % of gypsum content. The proctor mould diameter is 10 cm and height 11.7 cm. The inner volume is 945 cm^3. Weight of hammer is 2.5 kg and the height of fall of the hammer is 30 cm.

CHAPTER 4

RESULT AND ANALYSIS

Variation of Liquid Limit & Plastic Limit

Liquid Limit and Plastic Limit tests are performed on Rourkela soil by successive increment of percentage of gypsum by weight. Gypsum was added to the soil by 0.5, 1, 2, 5 and 10% by weight. The change in liquid limit and plastic limit due to increase in gypsum content is presented in Table 4.1 and Figure 4.1. It was noted that with increase in gypsum content both liquid limit and plastic limit of soil decreased.

Table 4.1. Variation of liquid limit and plastic limit due to increase in gypsum content

Gypsum content (%) by Weight	Liquid Limit (%)	Plastic Limit (%)
0	30.0	16.5
0.5	29.1	16.2
1	28.5	15.6
2	27.2	14.8
5	25.4	13.9
10	23.1	12.7

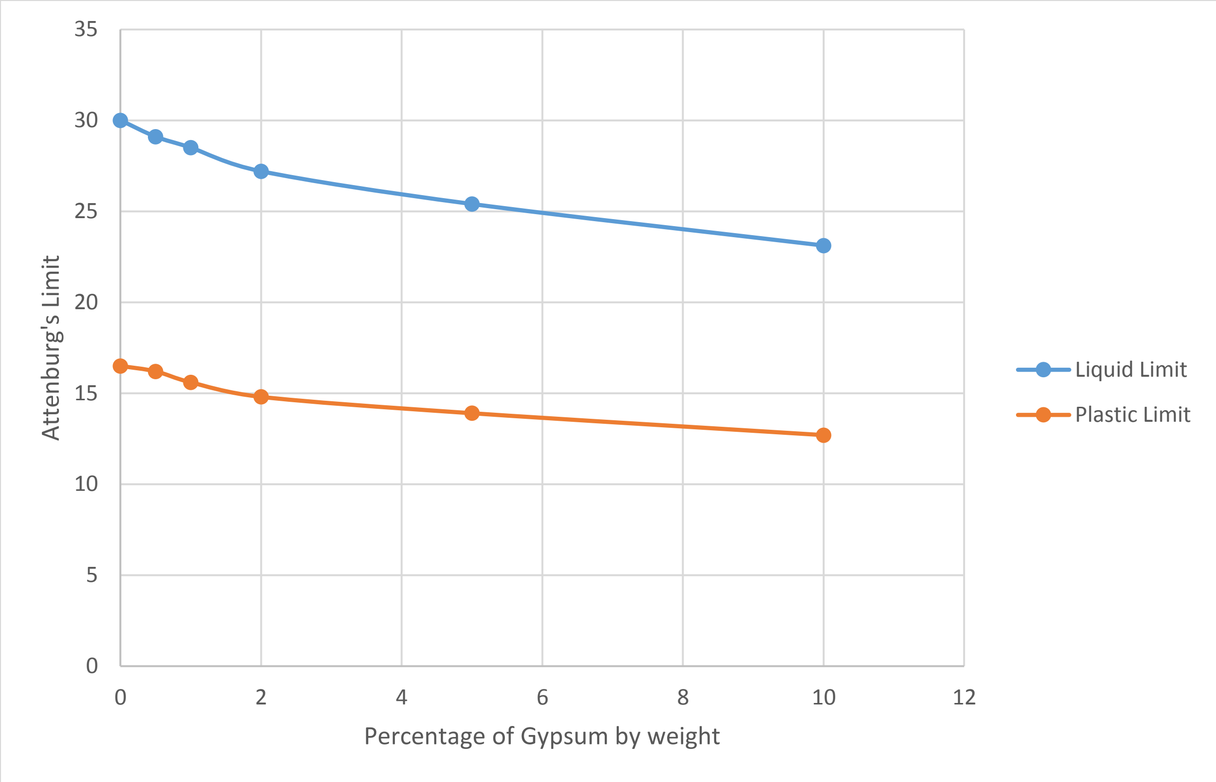

Figure 4.1. Change in liquid limit and plastic limit with increase in gypsum content.

Variation of Optimum Moisture Content and Maximum Dry Density

Standard Proctor Test is performed on Rourkela soil by successive increment of percentage of gypsum by weight. The test results are presented in Table 4.1 and in Figures 4.2 to 4.6 representing compaction curve with 0%, 0.5%, 1.0%, 5.0% and 10.0% addition of gypsum with soil. Maximum dry density (MDD) was found to be decreased from 1.82 gm/cc to 1.55 gm/cc. Optimum moisture content was found to be varying from 7.4% to 11.4%.

Table 4.2 Variation of OMC and MDD with various percentage of gypsum content.

Gypsum content (%) by Weight	OMC (%)	MDD (gm/cc)
0	10.4	1.82
0.5	7.4	1.78
1	9.4	1.72
5	9.4	1.62
10	11.4	1.55

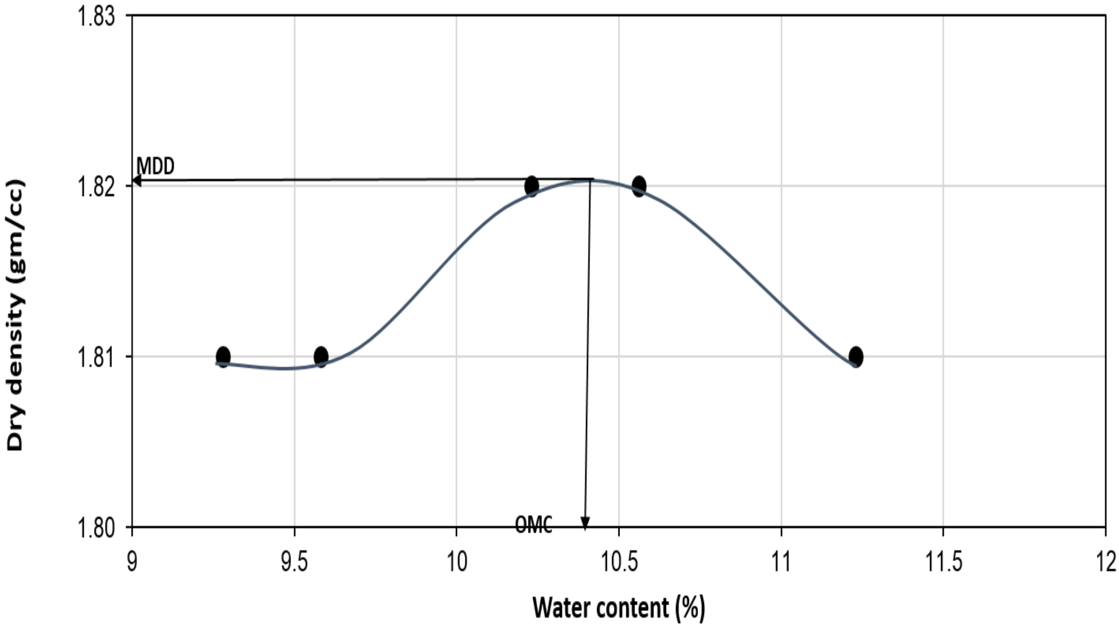

Figure 4.2 The compaction curve without adding gypsum

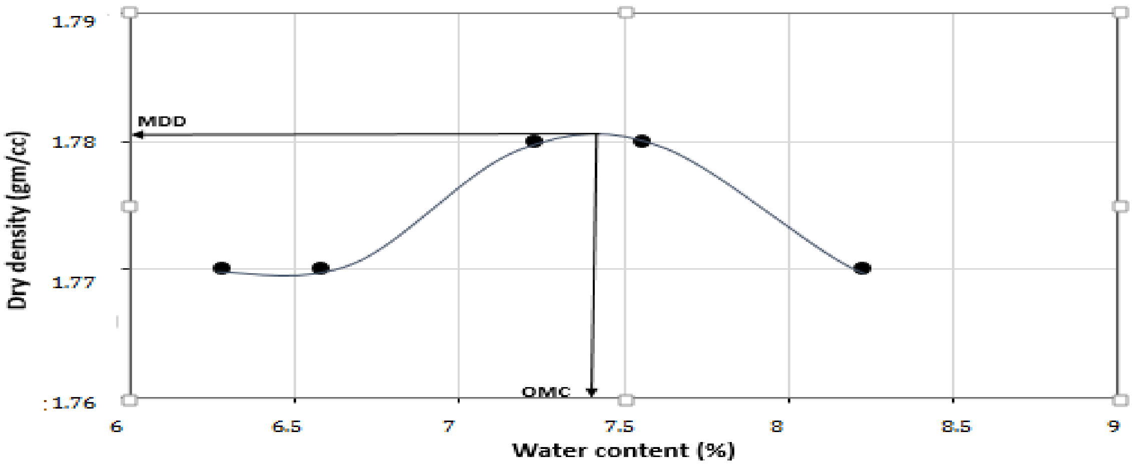

Figure 4.3 The compaction curve for 0.5% gypsum by weight.

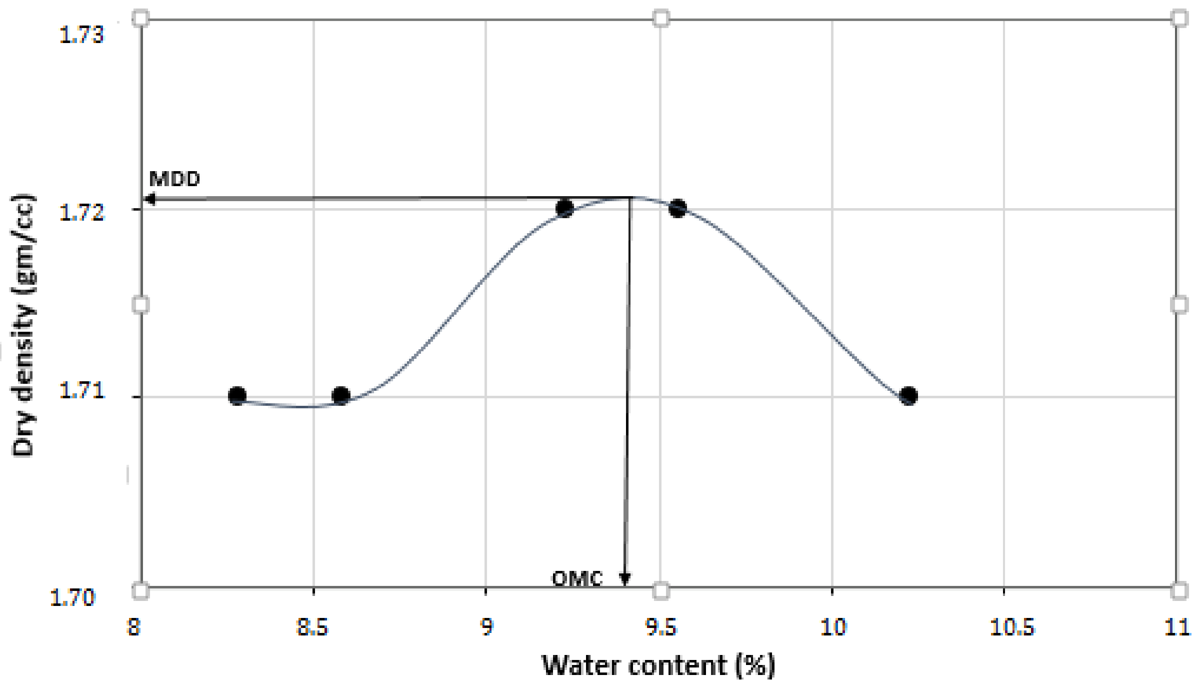

Figure 4.4 The compaction curve for 1% gypsum by weight.

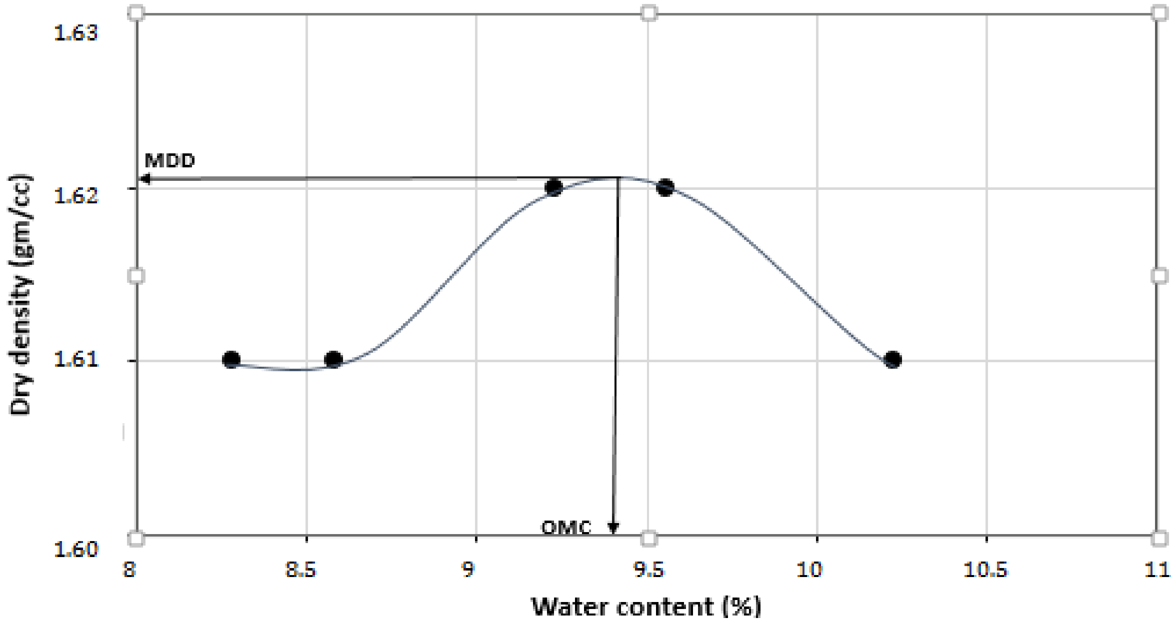

Figure 4.5 Compaction curve for 5% gypsum by weight.

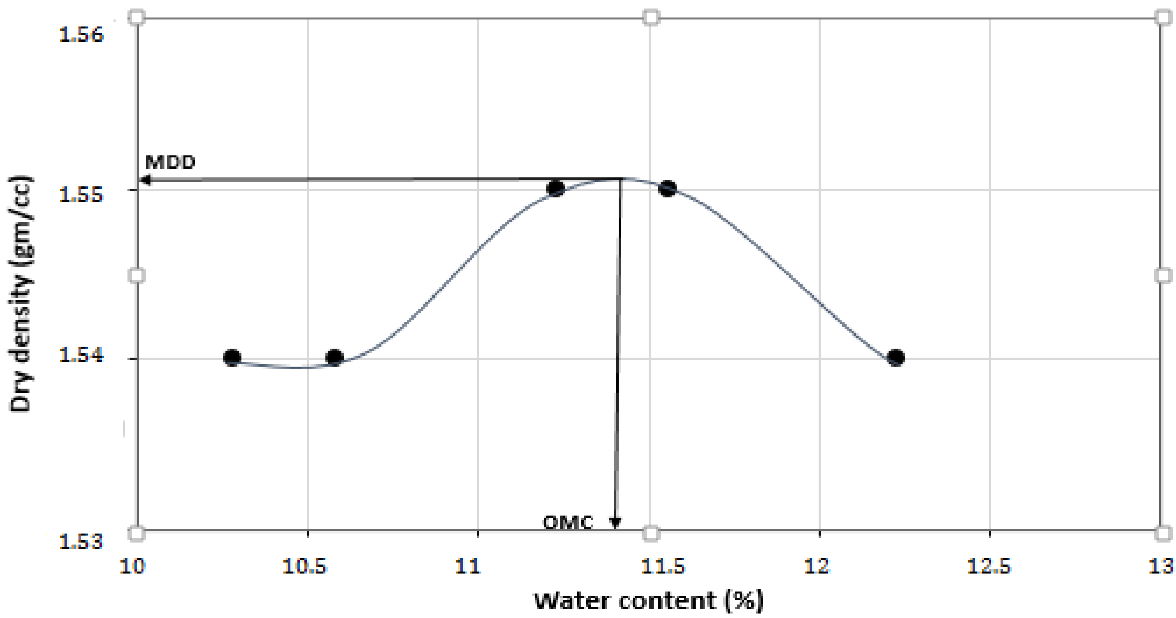

Figure 4.6 The Compaction curve for 10% gypsum by weight.

Comparison of OMC and MDD variation with percentage of gypsum content

Figure 4.7 and 4.8 represents change in Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) due to increase in gypsum content in soil. It was noted that with increase in gypsum content MDD decreased continuously. For Optimum Moisture Content (OMC), although some deviations were noted, however overall an increasing trend with increase in gypsum content was noted.

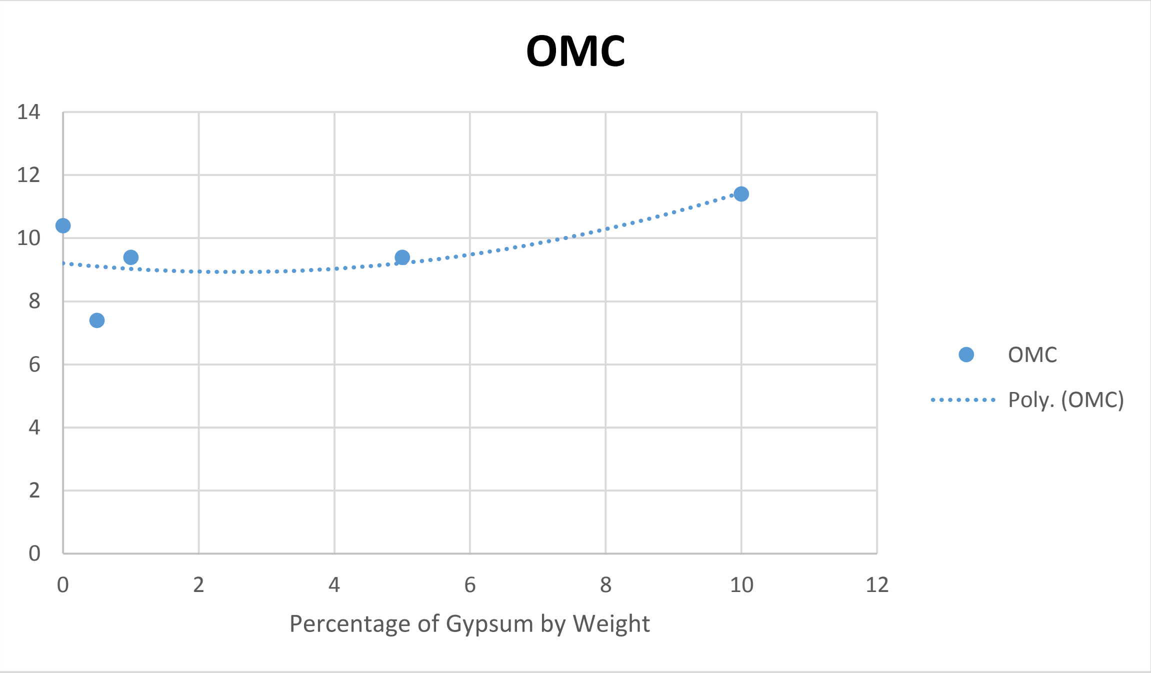

Figure 4.7. Change in optimum moisture content (OMC) with increase in gypsum content.

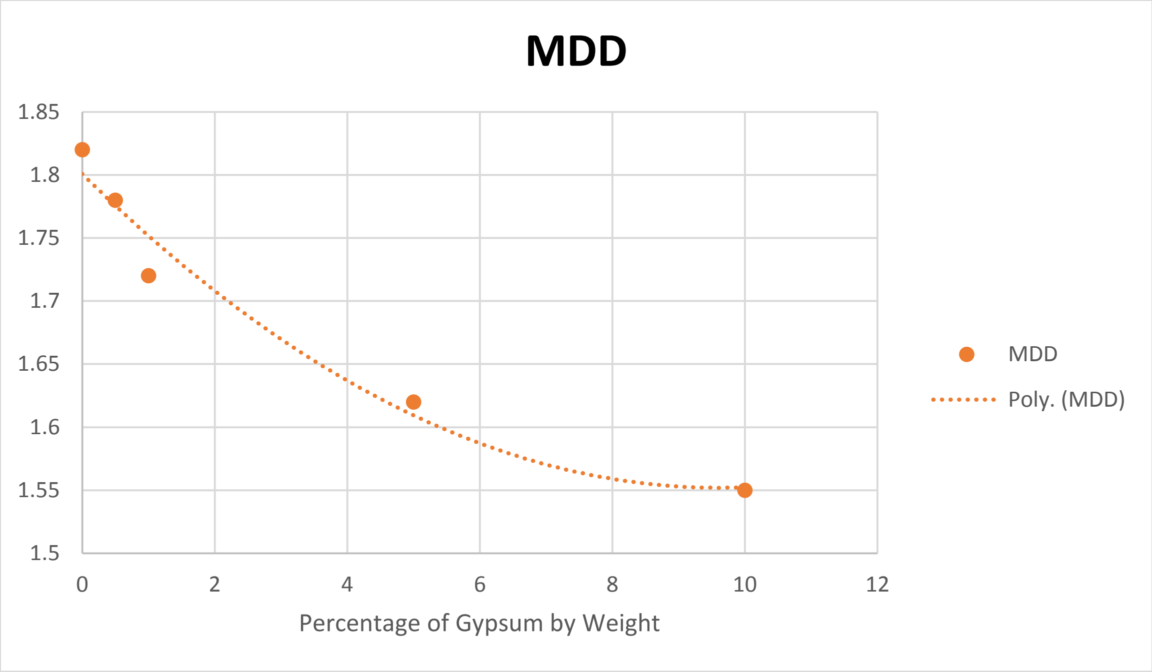

Figure 4.7. Change in Maximum Dry Density (MDD) with increase in gypsum content.

CHAPTER 5

CONCLUSIONS

Based on the laboratory tests carried out on a low plastic soil from Rourkela, the following conclusions can be drawn.

- The Liquid limit and plastic limit of soil was found to decrease with increase in the percentage of gypsum content.
- The Maximum Dry Density (MDD) was noted to decrease continuously on increasing gypsum content.
- Although, some deviation were noted, in general a trend of increasing Optimum Moisture Content (OMC) was noted with increase in gypsum content.

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