Faculty of Engineering

EFFECT OF COMPACTION ENERGY ON ENGINEERING CHARACTERISTIC OF COMPACTED SOIL

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EFFECT OF COMPACTION ENERGY ON ENGINEERING CHARACTERISTIC OF COMPACTED SOIL

MUHAMMAD IKRAM B UZIR ABDUL WAHAB

This Thesis Is Propose To

Faculty of Engineering, Universiti Malaysia Sarawak

For Fulfillment of The Requirements for Bestowal

The Degree of Bachelor of Engineering with Honours

(Civil Engineering)

2010

This project report is dedicated to lovely people surround me,

especially my mum,

my brothers and sisters,

nephews and nieces,

friends

and lecturers,

thank you so much for their love and support

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With the name of Allah the Most Gracious and the Most Merciful

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ABSTRACT

Soil compaction is a significant stage in construction. When field compaction is performed improperly, soil excessive settlement could occur and result in unnecessary maintenance costs or structure failure. The objective for this research is to study the effect of compaction energy to compaction characteristic of granular soil. Granular soil is widely used as a replacement soil when dealing with soft soil such as peat and very soft clay. Furthermore, granular soil is commonly used in pavement of runaway which requires strong base to sustain heavy load from vehicles. Compactive effort is one factor that affects the quality of compaction. Standard and Modified Proctor had been used to show the effect of compactive effort to the river sand and laterite soil samples. The study proved that the maximum dry density of soils increases when the compactive effort increases which also contributed to higher shear strength.

ABSTRAK

Pemadatan tanah merupakan proses yang penting dalam pembinaan. Ketika pemadatan lapangan dilakukan tidak mengikut prosedur, pemendapan berlebihan boleh berlaku dan menyebabkan kos penyelenggaraan yang tidak tinggi atau kegagalan struktur. Tujuan kajian ini adalah untuk mempelajari kesan tenaga pemadatan terhadap ciri-ciri pemadatan tanah granular. Tanah granular digunakan secara meluas sebagai tanah pengganti terhadap tanah lembut seperti tanah gambut dan tanah liat yang tertentu. Tambahan lagi, tanah granular biasanya digunakan sebagai lapisan landasan kapal terbang yang memerlukan asas yang kuat untuk menampung berat yang berlebihan. Tenaga pemadatan adalah salah satu faktor yang mempengaruhi kualiti pemadatan. Proctor piawaian dan Proctor diubahsuai telah digunakan untuk menunjukkan kesan usaha tenaga pemadatan terhadap sampel pasir sungai tanah laterit. Kajian membuktikan bahawa kepadatan kering maksimum tanah meningkat apabila tenaga pemadatan meningkatkan yang juga memberi kesan terhadap kekuatan ricih yang lebih tinggi.

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G_s	-	Specific Gravity
m_s	-	Mass of Soil / Solid
V_s	-	Volume of Solid
ρ_w	-	Unit Weight of Water
e	-	Void ratio
n	-	Porosity
W	-	Moisture content / Water Content
V_s	-	Volume of Solid
LL	-	Liquid Limit
PL	-	Plastic Limit
γ	-	Unit weight of compaction
γ_d	-	Dry unit weight
CI	-	Clay intermediate

EFFECT OF COMPACTION ENERGY ON ENGINEERING CHARACTERISTIC OF COMPACTED SOIL

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Abstract

Soil compaction is a significant stage in construction. When field compaction is performed improperly, soil excessive settlement could occur and result in unnecessary maintenance costs or structure failure. The objective for this research is to study the effect of compaction energy to compaction characteristic of granular soil. Granular soil is widely used as a replacement soil when dealing with soft soil such as peat and very soft clay. Furthermore, granular soil is commonly used in pavement of runaway which requires strong base to sustain heavy load from vehicles. Compactive effort is one factor that affects the quality of compaction. Standard and Modified Proctor had been used to show the effect of compactive effort to the river sand and laterite soil samples. The study proved that the maximum dry density of soils increases when the compactive effort increases which also contributed to higher shear strength.

Keywords: Soil compaction, compaction energy, Granular soil.

I. Introduction

Compaction of soil is the process by which the solid particles are packed more closely together, usually by mechanical means, thereby increasing the dry density of the soil. The state of compaction is measured in terms of dry density. This achieve by a process of compaction is found to depend upon energy expended during compaction, and also on the water content during compaction (Berry and Reid, 1987).

In this research, the granular soils will be used as an experimental material in the determination of its characteristic. Granular soils, for example sand and gravel normally is use as a replacement material to replace the soft soil. Mat foundation can be applied to this type of soil but if there was a little or no sand and gravel at the site, the building must be placed on piles to firm soil. Without proper soil compaction, many concrete structures are doomed to perform poorly (Lambe and Whitman, 1979).

Braja M. Das (1941) studied that for sands, the dry unit weight has a general tendency first to decrease as moisture content increases, and then to increase to a maximum value with further increase of moisture. The initial decrease of dry unit weight with increase of moisture content can be attributed to the capillary tension effect. At lower moisture content, the capillary tension in the pore water inhibits the tendency of the soil particles to move around and be densely compacted.

II. Objectives

1. To identify compaction parameters of granular soil.
2. To investigate the effect of compaction energy to soil shear strength.

III. Methodology

Since this study is fully base on laboratory work, the soil samples were collected from Kota Samarahan area for the laterite soil and from the Sungai Sarawak for the river sand. The laterite soil was taken at the nearside of new highway to be ahead to Kg Baru, Kota Samarahan. The sample is taken to the laboratory and the tests conducted according to British standards. The test is divided into two different tests which are physical properties test and engineering test. The classification test is to determine the index properties such as specific gravity, water content or etc. There are two test conducted in engineering test which is Proctor test and direct shear test.

IV. Results and Discussion

Results on Physical Properties

Natural Moisture Content

The natural moisture content or water content of samples is determined by using oven drying method. From the calculation, the average natural moisture content of river sand is 23.3% while for laterite soil is 30%.

Particle Size Distribution

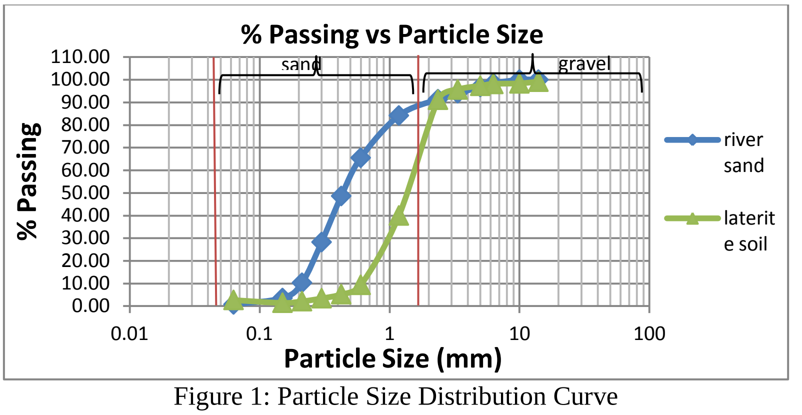

Figure 1: Particle Size Distribution Curve

Sieving test was done to identify percentage of gravel, sand, silt, and clay. For river sand sample, it is obviously the sample contain high percentage of sand which 86.28% and gravel 10% while laterite soil shows 77.28% of sand and 19.11% gravel.

Atterberg Limit Test

Table 1: Atterberg Limit Value for Samples

Sample	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
Laterite Soil	0.41	0.25	0.16

Through Atterberg limit test, liquid limit and plastic limit for the samples will be known. Determination of liquid limit is referring to moisture content at 20mm cone penetration while plastic limit is defined as average of the moisture content (%).From the plasticity chart laterite soil is fall under Clay Intermediate (CI) range. The range is between 40 to 60%.

Specific Gravity

Table 2: Specific Gravity Value

Sample	Gs
River sand	2.64
Laterite soil	2.57

The data show that *Gs* value of river sand is higher than the laterite soil. The value meets the standard range for sand which is 2.6-2.7.

Results on Engineering Properties

Compaction Characteristics of Two Samples of Soil

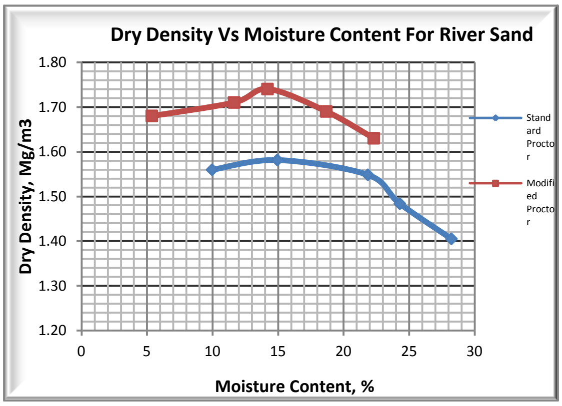

Figure 2: Dry density versus moisture content curve for river sand

Figure 2 shows compaction curve of compacted river sand. It was described that optimum moisture content (OMC) and maximum dry density (MDD) using standard Proctor were 16% and 1.59 Mg/m^3 respectively. Modified Proctor produced better result of OMC and MDD which 14.2% and 1.74 Mg/m^3 respectively.

As the weight hammer increase and higher the drop height is, the deeper compaction will be and resulting increase of bulk unit weight. This contributes to higher MDD of modified Proctor compares to standard Proctor.

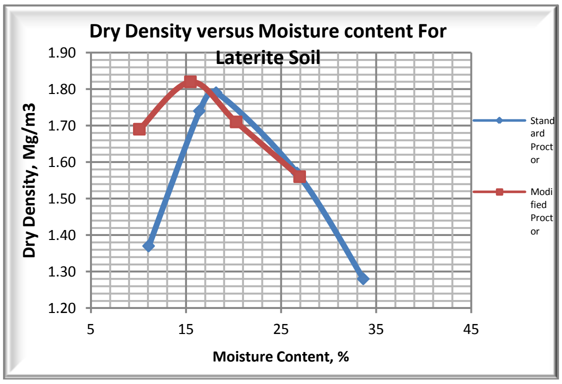

Figure 3: Dry density versus moisture content curve for laterite soil

Figure 3 illustrates compaction curve of compacted laterite soil. It was observed that OMC and MDD of laterite soil using standard Proctor test were 18 % and 1.78 Mg/m^3 respectively. On the other hand, Modified Proctor test produced better results which OMC is 15.5 % and MDD is 1.82 Mg/m^3.

The relation between the moisture content and the dry density of soil is to obtain the maximum dry unit weight and the optimum moisture content for a soil. The maximum dry unit weight is obtained when there is no air void space, which is when the degree of saturation equals 100%. The dry density of laterite soil is higher than the river sand. It is means that the soil particle of laterite soil is more compact and closely to each other.

It can be summarized that experimental results show increase in compaction energy applied to both sample produces better maximum dry density. Meanwhile, moisture content will be decreased. It was also observed that river sand sample was well compacted compare to laterite soil sample.

Shear Strength Parameters of Compacted Soils

Figure 4 shows shear stress versus strain curve for standard and modified Proctor of river sand. Shear stress is increased when the load increased. However, shear stress for modified Proctor sample is lower than standard Proctor sample. This is because the more compaction energy applied will produce parallel orientation to soil particle. Thus, soil particles become close to each other and shear strength increased. From the curves, maximum shear stress every load applied was obtained and will be used to determine shear strength parameters.

Figure 5 illustrates shear stress versus normal stress for standard and modified Proctor of river sand sample. It was observed that cohesion for standard Proctor of river sand is slightly different from modified Proctor which standard Proctor is 0kN/m^2 and modified Proctor is 8kN/m^2. the friction angle for standard Proctor is 27.77° and modified Proctor is 20.3° which is lesser than standard.

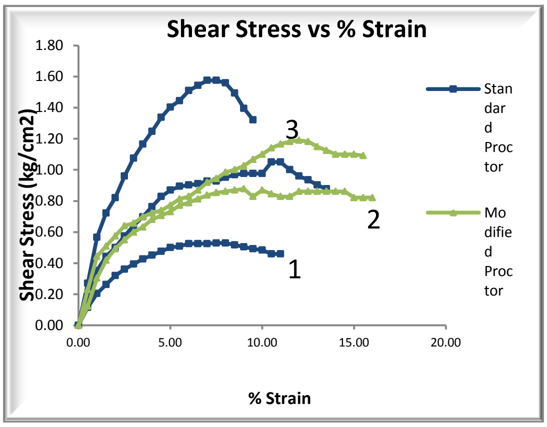

Figure 4: Shear Stress versus Strain Curve for Standard and Modified Proctor of River Sand

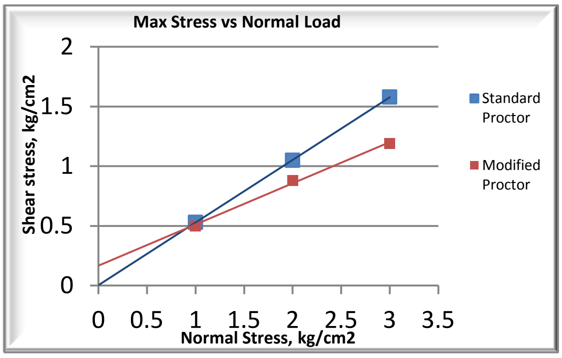

Figure 5: Shear Stress versus Normal Stress for Standard and Modified Proctor of River Sand

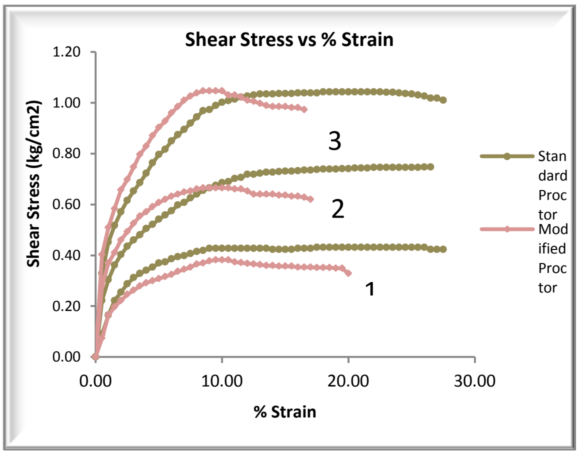

Figure 6: Shear Stress versus Strain Curve for Standard and Modified Proctor of Laterite Soil

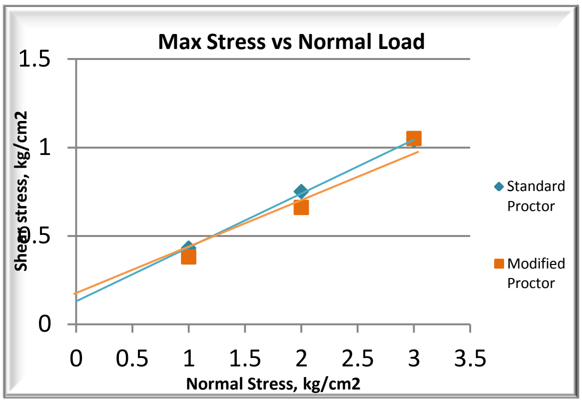

Figure 7: Shear Stress versus Normal Stress for Standard and Modified Proctor of Laterite Soil

Different in normal stress applied will give different soil strength. Differential in compaction effort also influence the soil strength. When compaction energy applied is higher, the more strengthen the soil.

From the figure 4.8, the value of cohesion, c for the modified Proctor is higher than standard Proctor which is 20 kN/m^2 and 13 kN/m^2 respectively. The higher value of *c* is shows the strength value of soil internal forces to hold soil particles together with the soil mass. The friction angle for standard Proctor is 16.87° which much greater than 15.82° for modified Proctor. It shows that when the compaction energy applied becomes greater, the value of friction angle will become smaller.

Summary of Findings

From the experimental works done, it can be observed that natural moisture content of laterite soil is higher than river sand which is 30% and 23.33% respectively.

Both river sand and laterite soil is classified as CI (clay intermediate) based on plasticity chart. The specific gravity of both samples is fall under granular soil range which is 2.6-2.7. Specific gravity for river sand is 2.64 while laterite soil is 2.57 (acceptable).

Maximum dry density of modified Proctor for both samples is higher than standard Proctor test. This shows that when compactive effort increased, dry density also increased. The optimum moisture content is decreased when increased in compaction energy thus causing increased in soil shear strength.

V. Conclusion

From the analysis and results obtained, some physical and engineering parameters were generated. These parameters are leads to achieve the objective of this paper and get better understanding about the soil compaction. Conclusions that can be made are:

i. Increased in compactive effort will increase the maximum dry density and decreased optimum moisture content. It is proven by the analyses that have been made for both samples. When the higher energy applied to the soil, the air void between the soil particles is decreases and water is hard to entering the soil, hence increases the maximum dry density.
ii. When the weight and height of hammer are increase, it gives more compaction energy to the soil. The soil particle will be close to each other and causing the bulk unit weight heavier. The compaction energy per unit volume (E) used for the standard Proctor test can be described as E = [(No of blows/layer) x (no of layers) x (weight of hammer) x (drop of hammer)]/ volume of the mould. If the compactive effort per unit volume is altered, the moisture unit weight curve is also altered.
iii. Cohesion value, c between standard and modified Proctor for both sample is not show a big different but angle of friction, φ is decrease as the energy increase.
iv. The normal stress applied will affect the soil strength. Soil strength will increase as the increase in normal stress.
v. Shear stress of river sand is higher than laterite soil. River sand gives more stabilization than laterite soil.

It is important to have deep understanding on compaction energy and its effect to the soil structure.

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CHAPTER 1

INTRODUCTION

1.1 Background

Compaction of soil is the process by which the solid particles are packed more closely together, usually by mechanical means, thereby increasing the dry density of the soil. In construction, this is a significant part of the building process. Improper compaction techniques can cause soil having settlement and the maintenance cost will increase or structure will failure. Almost all types of building sites and construction projects utilize mechanical compaction techniques. The state of compaction is measured in terms of dry density. This achieve by a process of compaction is found to depend upon energy expended during compaction, and also on the water content during compaction (Berry and Reid, 1987).

In this research, the granular soils will be used as an experimental material in the determination of its characteristic. Granular soils range in particle size from .003" to .08" (sand) and .08" to 1.0" (fine to medium gravel). Granular soils are known for their water-draining properties. The response of soil to moisture is very important, as the soil must carry the load year-round. Rain, for example, may transform soil into a plastic state or even into a liquid. In this state, soil has very little or no load-bearing ability.

Granular soils, for example sand and gravel normally is use as a replacement material to replace the soft soil. Mat foundation can be applied to this type of soil but if there was a little or no sand and gravel at the site, the building must be placed on piles to firm soil.

One of the common uses of granular soil is in the pavement of roads or air field. The base course of the pavement consists of gravel commonly, but in certain situation like in the desert, there was a shortage of gravel but abundance of desert sand. Under these circumstances, it was more economical to improve properties of the soil than to use gravel over large distances.

1.2 Problem Statement

In this world, soil is the most plentiful construction material and it is essentially locally available construction material in any region. The civil engineer must select a proper type of soil and the method of placement, and then control the actual placement. Soils are usually compacted by using compaction machineries for example vibrator rollers and pneumatic rollers. Without proper soil compaction,