ZERO AZANIA (Pty) Ltd

Reg.No. 2012/033424/07 **Telephone** 011 902 7941 **Portal** www.zero-azania.co.za

Leaders in super-basement and bulk platform construction

INFORMATION SHEET 3a

COMPACTION

Information sheet on soil compaction classification

INTRODUCTION

Zero Group has successfully completed numerous high profile Bulk Excavation and Platform contracts across South Africa, and has gained extensive insight and experience on the soil compaction classifications as most commonly required in in-situ treatment and fill operations.

The objective of this information sheet is to provide clarity regarding soil compaction classification and to broaden the readers' understanding of process and the terminology used within the industry.

Furthermore we will highlight some of the required compaction classifications that needs to be met as specified in COLTO.

What is compaction?

Compaction is the process whereby particles within a soil sample are pressed closer together to increase the interlocking properties between the various solid particles. In order to achieve this, a force (impact, rolling, vibration) is needed to overcome particle resistance and densify the material.

The efficiency of this process is dependent upon the compacting effort applied to the soil, as well as the inherent friction between the various size particles within the soil sample. To increase compaction efficiency and reduce friction of particle resistance, water is added as a lubricant. The amount of water required is determined from laboratory tests and is referred to as the optimum moisture content (OMC), which is a percentage of the soil's mass.

In general the following relationships can be found between compaction effort and moisture:

- Using a large force requires less moisture
- Using a small force requires more moisture
- Coarse material requires less moisture
- Fine material requires more moisture

Density is one of the key measures used when analysing compaction efforts and efficiency in the field, thus it is important to understand what density refers to.

What is meant by the density of soils?

Density is a measure of the degree of the togetherness of particles within soil and highlights the interlocking capability of the soil. It is defined as dry density when only the mass of the solid particles per unit volume of the soil is measured and wet density when the mass of the water is also taken into account.

How are soils made up?

Soils are made up of air (gas), water and solids as seen in the Figure 1A and Figure 1B:

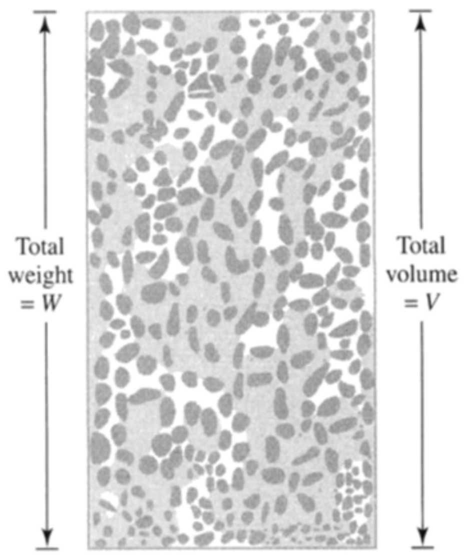
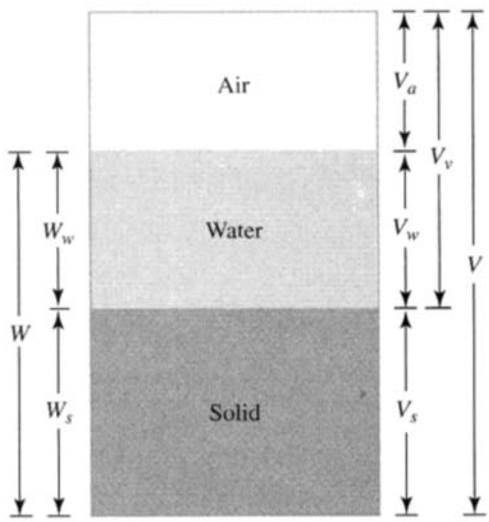


Figure 1A: Soil Sample Illustration



Where:

W	= Total Weight	V	= Total Volume
W_a	= Weight of air = 0	V_a	= Volume of air
W_w	= Weight of water	V_w	= Volume of water
W_s	= Weight of solid	V_s	= Volume of solid
ρ	= Density (W/V)	V_v	= Volume of voids

Figure 1B: Phase diagram representing the various components taken into account when calculating density.

INFORMATION SHEET 3b

COMPILED BY

P. Hoffmann

Geoplan

082 374 7052

philip@geoplan.co.za

K. Vlok

Zero Azania

kobus@zero-azania.co.za

082 094 3818

J. Smit

Zero Azania

jaco@zero-azania.co.za

072 262 1260

How is the density of a soil sample determined?

Field density is usually determined by either the sand replacement test, or by means of a nuclear gauge. In the laboratory, the primary soil sample collected in the field is spread over a large surface and dried out in the sun or oven. Multiple secondary soil samples of equal weight are prepared from this primary soil sample and a different amount of moisture is then added and mixed into each samples, where after they are subjected to one of the following compaction effort tests:

Modified AASHTO density	55 blows in 5 layers with a hammer (4,536kg) that falls over a distance of 457,2mm, energy = 0,750 kWh/m3
NRB density	25 blows in 5 layers with a hammer (4,536kg) that falls over a distance of 457,2mm, energy = 0,340 kWh/m3
Proctor density	55 blows in 3 layers with a hammer (2,495kg) that falls over a distance of 304,8mm, energy = 0,165 kWh/m3

Thereafter each sample is weighed and a bell curve graph is drawn up, which compares the different moisture contents with the dry density of the material. From this graph both the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) can be determined.

Furthermore, should all three of the compaction test be carried out on a sample with the same moisture content added to it, the following can be deduced from the results: 1) OMC varies with effort and material; and 2) OMC a laboratory value and does not apply in the field.

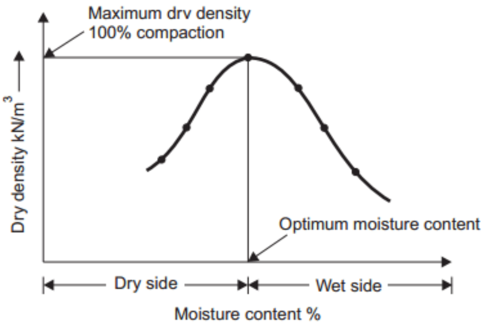


Figure 2: Compaction Bell Curve (MDD vs OMC)

How is compaction effort specified and assessed in the field?

The field density is (ρ_{field}) is measured using a nuclear gauge and then compared to the standard density obtained in the laboratory (ρ_{lab}) and expressed as a percentage of Maximum Dry Density. This is referred to as relative compaction (RC) and is calculated as RC = ρ field / ρ lab.

Bulking and Shrinkage

In its in-situ, undisturbed or bank state, soil is compressed and consolidated into equilibrium under gravity and overburden material. Excavation disturbs the balance between the three phases of the material, by introducing additional air into the soil matrix, while simultaneously loosing moisture to the atmosphere. This causes the soil to bulk or swell in volume, while reducing in density. The degree of bulking is dependent on the percentage of moisture retained within the soil matrix and the particle size of the fine aggregate. The Bulking Factor represents the relationship between change in volume of the material before and after excavation. For example, a 1.0 bank cubic meter of material could bulk by 40%, producing 1.4 loose cubic meters of material. Therefor allowance should be made in transport costs to transport 40% more material from the excavation source to the stockpile, spoil or fill area.

However when soil is compacted, additional moisture is introduced into the soil matrix as lubricating agent to increase workability. The compaction process then forces out the excess air and moisture. This densifies the material, while causing a reduction in volume. The degree of shrinkage is dependent upon a combination of the saturation potential of the soil and the compaction effort applied to it. The Shrinkage Factor represents the relationship of the change in volume before and after compaction. For example, 1.4 loose cubic meters of material could shrink by 60% after compaction, producing a fill layer of only 0.875 thigh cubic meters of material. This means that 60% more loose cubic meters of material will be required to create a layer or fill a hole equal in size to 1.0 tight cubic meter of material.

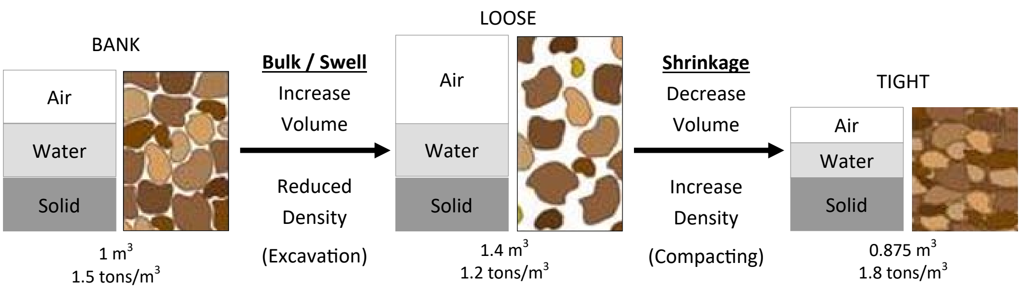


Figure 3: Bulking vs Shrinkage

Conclusion

Densities calculated in the laboratory are not practically achievable in the field due to many variables affecting the compaction efforts, i.e. weather, in-situ soil moisture, etc. Over-compacting and/or introducing excessive moisture can be more destructive to a layer. Relative compaction is only a measure used to determine whether a specific compaction specification has been met or not. Bulking and shrinkage are important factors to remember when costing excavation and filling operations.