EFFECT OF SOIL MOISTURE AND AXLE LOAD ON DEPTH OF COMPACTION

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Abstract

The effect of soil moisture and axle load on depth of compaction was studied on loamy soil. It was observed that greater axle loads and wet soil conditions increase the depth of compaction in the soil profile. Compaction caused by heavy axle loads on wet soils can extend to depths of more than two feet.

Introduction

In many studies, it has been reported that soil compaction caused an increase in soil bulk density and soil strength, resulting in poor hydraulic and physical soil properties (Carter, 1990; Smith, 1997 & Arridsson, 1998).

Soil compaction, which refers to an increase in soil bulk density or decrease in soil porosity as a result of applied loads or pressure is a function of both compactive effort and the water content (Gill, 1959; Adelabu & Uno, 2001, 2004). Greater axle loads and wet soil conditions increases the depth of compaction in the soil profile. The total axle load, as well as contact pressure between the tire and the soil, affects subsoil compaction. As equipment weight increases, tire size also increases (Voorhees *et al,* 1986). It has been reported by Petersen et al, 1986, that deep or sub surface soil compaction is caused by tractors with high axle weights. As tractors becomes heavier, compaction stresses go deeper into the soil. Also, soil is more compressible when wet. Traffic during high moisture conditions may compact soil, whereas the same traffic under dry conditions will not. As soil dries, it has higher soil strength, making it less susceptible to compaction, and supports traffic more readily than a wet soil. The objective of this study is to evaluate the effect of compactive loads on soil at different moisture contents at different depth.

Materials and Methods

Five sets of PVC tubes of length 30cm and 7cm diameter each filled with soil samples identified as loamy were subjected to different levels of compaction (5,15 and 25 blows ,equivalent to pressures of 100,150 and 150Nm^{-2} respectively) using a proctor hammer at five different moisture levels at depths of 12, 14,16cm in an open field of Bwari Area Council, Abuja. The dry Bulk density and optimal moisture contents were determined by weight.

Theoretical Considerations and Calculations

Soil compaction occurs when soil particles are pressed together, reducing pore space between them (Adelabu & Uno 2001). Heavily compacted soil contain large pore and have a reduced rate of both water infiltration and drainage from the compacted layer. In addition, the exchange of gases slows down in compacted soils causing an increase in the likelihood of aeration-related problem (Frisby et al, 1993). Soil compaction increases soil strength, the ability of soil to resist being more by an applied force (Petersen et al 1996).

Pressures exerted on the soil surface depend on the characteristics of the load of soil surface.

The porosity [P] of the soil is the ratio of total (air plus water) pores volume to total soil volume, usually expressed in per cent.

$$\text{Prorosity (P)} = 1 - DBD/DSG \quad \ldots\ldots \quad (1)$$

Where DBC is the dry bulk density of the soil and DSG is the density of individual soil grain.

The proportion of total volume occupied by air-filled pores (PA) can be found using the formula:

$$PA = \frac{\text{Volume of air-filled pores}}{\text{Total soil volume}} \quad \ldots\ldots \quad (2)$$

$$PA = \frac{\text{Porosity} - BD \times MC}{\text{Density of Water}} \quad \ldots\ldots \quad (3)$$

Where MC is the moisture content given as:

$$MC = \frac{\text{Weight of Water in a Soil Sample}}{\text{Dry Weight of Soil Sample}} \times 100\ \% \quad \ldots\ldots \quad (4)$$

Results and Discussions

The soils used in this study have the same texture and organic matter content. Our results indicated that the dry density of soils increased in compaction level for all PVC tubes, and the 25 hammer blows produced the highest density values. However, the optimum moisture content, which is the moisture content where the maximum dry density was reached, decreased as the number of hammer blows is increased.

Fig. 1 shows the relationship between moisture content and dry bulk density for one of the PVC tubes soils samples studied. As it can be seen, the dry density increased with increasing moisture contents until the maximum dry density was reached and decreased after that point. The results of the analysis of variance showed that the efforts of soil type, and the number of blows on maximum dry density affect the porosity of the soil.

In general, soils with high amount of sand have the highest maximum dry density and the lowest optimum moisture content, but soils with finer textures have the highest optimum moisture and lowest dry density values (Smith et al, 1997). The effect of the number of hammer blows on soil porosity was very clear. While the mean porosity value was 54.43 (16 cm) at 5 hammer blows, it went to 50.62 (14cm) depth and 49.02 (12 cm depth) at 15 and 25 blows respectively.

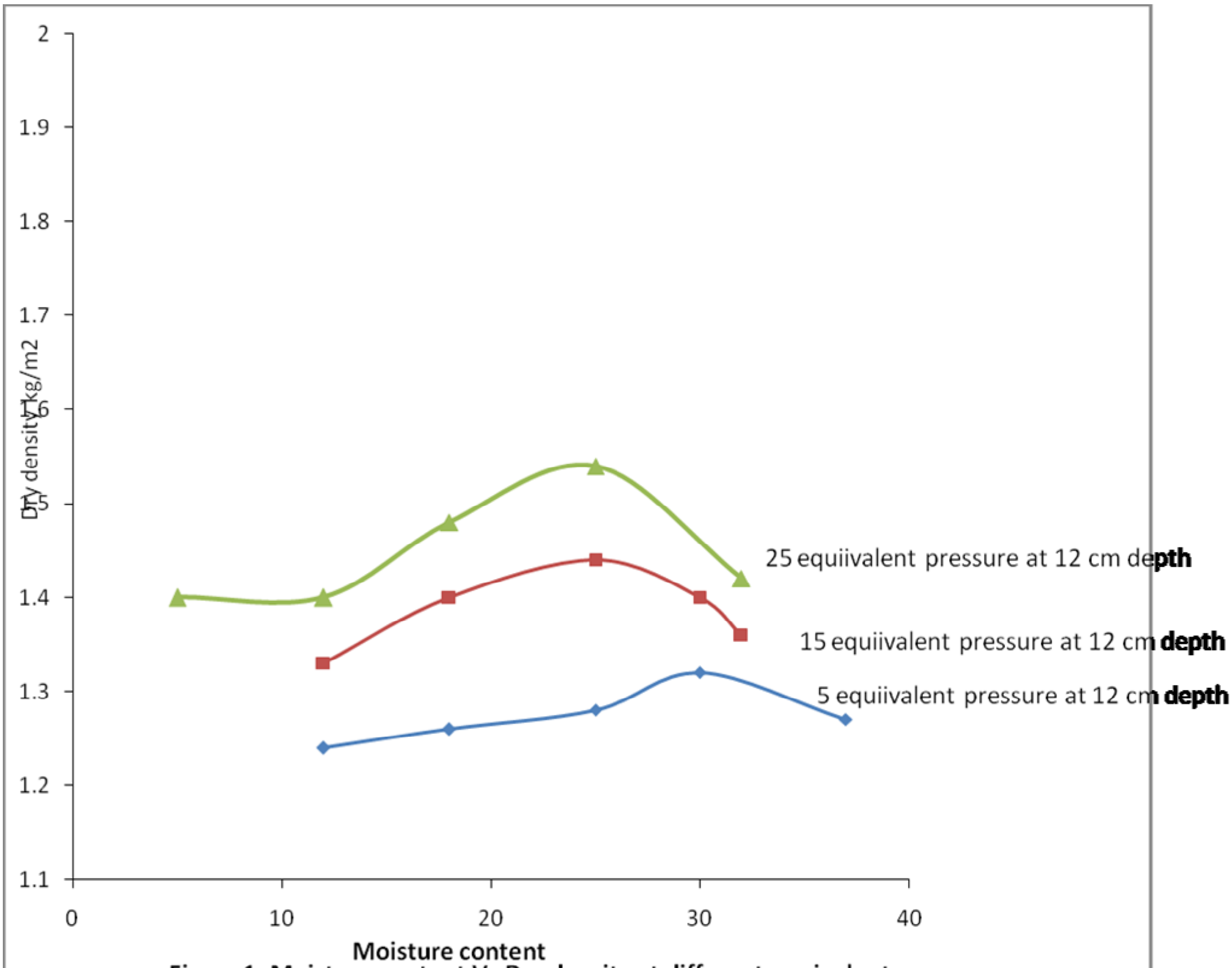

Figure 1: Moisture content Vs Dry density at different equivalent pressure

Conclusion

Our results indicated that the dry density of soils increased with increasing compaction level for all soils, and the 25 hammer blows produced the highest value of density. However, the optimum moisture content, which is the moisture content where the maximum dry density was reached decreased as the number of hammer blows increased.

References

Adelabu, J. S. A. & Uno, U. E. (2003). Combined effect of soil moisture and soil compaction on maximum soil temperature. *Nigerian Journal of Physics, 15(2).*

Adelabu, J. S. A. & Uno, U. E. (2004). Effect of soil moisture and soil diffusivity: *Zuma Journal of Pure and Applied Sciences 6(1).*

Arridsson, J. (1998). Influence of soil texture and organic content on bulk density, air content, Compression index and crop yield in field and Laboratory compression experiments. *Soil and Tillage Research, 49, 159-170*

Carter, M. R. (1990). Relative measured of soil bulk density to characteristics compaction in Tillage studies on fine sandy loams. *Canadian J. of Soil Science, 70, 425-433*

Gill, A. J. (1967) Compaction Pattern of Hawallian Soils. *Agric Mec. 4:30-37.*

Frisby, J.C. (1993). *Soil compaction: The silent thief.* Published by University of Missouri Columbia G. 1630.

Petersson, M., Ayers, P. & Westfall, D. (1996). Managing soil compaction. *J. of Chemical and Bio Resource Engineering, 2(96).*

Smith, C. V. & Arridsson, M. (1997). Soils properties affecting compatibility and compressibility. *Soil and Tillage Research, 43, 335-354.*

Voorhees, W., Sents, C. & Nelson, W. (1986). *Effect of surface compaction on yield.* Published by Communication and Education Technological Services, University of Minnesta Extension Services.