A STUDY OF FIFTEEN CONSTRUCTION SITES

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ABSTRACT
Unintended compaction of soils is due to inadvertent construction traffic. Fifteen construction sites were visited, and soil compaction and bulk unit weights measured from the soil surface to depths of 1.0m, at 0.2m intervals using speedy moisture testers/core cutters. Test results show that the soils were heavily compacted at depths from 0.3m - 0.8m. Suggestion are therefore made for a new attitude to soil compaction on construction sites.

INTRODUCTION

Soil compaction increases bulk unit weights and decrease porosity (Craul 1992; Harris 1971). Plant growth is inhibited by these effects (Patterson 1977; Veihmeyer and Hendrickson 1948; Zimmerman and Kardos 1961).

There are two categories of compaction viz: deliberate and unintended. Deliberate (or intended) compaction is done to densify the soil in order to secure physical soil stability for structures; whereas, unintended compaction is due to inadvertent construction traffic.

Many efforts have been made in the area of preventing soil compaction by either protecting (Lichter and Lindsey 1994) or ameliorating (Day and Bassuk 1994) the soil, but they have largely been failures. Even in temperature climates, natural processes of freeze - thaw have questionable capacity to reduce soil compaction (Hakansson and Reeder 1994). The focus on new construction sites therefore, must be preventing both deliberate and unintended compaction .

In Nigeria, most building activities are on former farmland, having topsoil organic content of 4-5%, which is considered unsuitable construction material, and usually stripped before actual building process begins. It is on such site that the degree of unintended soil compaction was investigated.

MATERIALS AND METHOD

Fifteen construction sites were randomly selected as described by Randrup 1996 and Randrup and Dralle 1996. Five sites were in shell Petroleum Development Company (SPDC) of Nigeria, flow stations with few large structures per site. Ten sites were in SPDC remote integrated facility with dense housing covering about 35-45% of the site.

Special tests areas at each construction site were selected by considering terrain, utility lines and planting areas. Test areas were selected where construction traffic was not expected. Nearby fields were used to represent the site conditions before the building activity began. Nine control areas (fields) were selected.

Bulk unit weights were measured on one to four test areas on each construction site (35 test areas in all) and on all nine control areas. Measurements were made from the soil surface to depths of 1.0m (approx. 3 feet) at 0.2m intervals (approx. 8 inches). In order to obtain a fair representation in the expected layered and unhomogeneous soils (Hansen et al), bulk unit weights were estimated three times at each depth in every test area. The numbers of sub-samples at each depth are shown in table 1.

Table 1. Average soil bulk unit weights on construction sites and control sites.

Average bulk unit weights surface to 1.0m						
Depth	**Construction sites**			**Controls**		
	n	**kN/m^3***	**std**	**n**	**kN/m^3***	**std**
0.2m	**75**	**16.4**	**0.27**	**27**	**17.6**	**0.17**
0.4m	**75**	**18.1**	**0.28**	**27**	**17.7**	**0.25**
0.6m	**73**	**17.5**	**0.23**	**27**	**17.7**	**0.24**
0.8m	**65**	**17.8**	**0.18**	**27**	**18.5**	**0.25**
1.0m	**30**	**17.9**	**0.24**	**23**	**19.6**	**0.19**

Results

The bulk unit weights in the top 0.3m of the soil were lower inside the construction sites than in the control locations. Bulk unit weights at depths of 0.4-0.8m were higher inside the construction sites than the controls. Below 0.8m, bulk unit weights inside the construction sites were lower than the controls. Outside the construction sites the bulk unit weights were similar in all depths.

Discussion

Nigerian top soils, particularly in the Niger Delta, exposed to annual farming, soil bulk unit weights of about 16-17 kN/m^3 are regarded as normal. In this survey higher bulk unit weights were found both inside and outside the construction sites (Table 1). Bulk unit weights above normal were also found by Hansen et al 1986, who estimated bulk unit weights between 15.9 and 17.2 kN/m^3 at depth of 0.1-0.9m.

The relatively high bulk unit weights found in this study may be due to the measurement technique used. Better technique may be measurement by a gamma ray single probe described in detail by Gardner 1986, and by Saare 1963.

Construction practice in Nigeria commonly involves stripping and stockpiling the upper 0.1-0.5m of soil during the grading phase. Following grading and construction, the soil is replaced. As this was the case on the sites examined, the higher bulk unit weights seen in the 0.4-.8m depth should be the result of unintended compaction.

Inspite of possible overestimation of bulk unit weights, the sub-soil was still compacted at depths of approximately 0.3m (1 foot). The compaction level found in these depths must be regarded as detrimental to root growth (Veihmeyer and Hendrickson 1948, Zimmerman and Kardos 1961 and Ziza et al 1980). The decrease in porosity occurring from compaction (Harris 1971) will, in many cases, also slow drainage. A zone of saturated soil could develop just above the sub-soil, also reducing plant growth.

When compaction is found at depths below the subsoil, equipment used to alleviate compaction must operate at great depths especially if the loosening procedure is carried out from the topsoil surface. In this study the soil had been loosened in 12 of the 17 cases, according to the contractors. Positive soil loosening effects could be found occasionally, but in the overall results shown in Table 1, no effects were found. Previously, several people have stated that alleviating soil compaction is difficult and usually not successful (Hakansson and Reeder 1994, Pittinger and Stamen 1990, Rolf 1994 and Smiley et al 1990).

Hakansson & Reeder 1994 said that if machines weighing more than 15 metric tons were used on clay soils, compaction to depths of 0.6m (2 feet) and below could be expected. On most construction sites machinery weighing from 17-25 tons is generally used (Randrup 1996). Dozers, scrapers, and motorgraders of the same size (and probably even larger) are used worldwide today.

Heavy machinery is a fact on construction sites. The focus on efficiency in all phases of modern living makes it difficult to foresee a change in attitudes toward the use of lighter machinery on construction sites. So, the ideal situation seen from a soil handling point of view cannot be achieved at present.

One way of dealing with the problem is to consider soil compaction as a fact on construction sites. The planner must take precautions every time a new landscape design is made. Once this done planners can inform developers, contractors, etc. about their intentions.

Given the results of this study and the standards of construction practice (i.e. stripping of top – soil and using heavy equipment) the following four steps are recommended in handling the soil compaction problem on construction sites:

- **I.** Expect the soil to be compacted
- **II.** Make all possible efforts to reduce the spread of compaction. Better to keep the compacted zones in certain areas than spread it all over.
- **III.** Fence off all possible future planting areas. Soils meant for future planting should be protected, just as existing trees should be protected.
- **IV.** Alleviate the compacted soil, knowing the alleviation is only helping the soil to reconsolidate itself, and that a real effect of the loosening may take many years.

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