COMPREHENSIVE STUDY ON CALCARIOUS FINE SAND COMPACTED WITH DIFFERENT TYPES OF ROLLERS

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ABSTRACT

A study has been made of the compactive performance of three types of rollers in compacting a calcarious fine sand at the optimum moisture content and the average dry densities measured after 1, 2, 4, 8, 16 and 32 passes were obtained. From the results, it was concluded that for any number of passes up to 32, the 8,00-ton smooth steel roller produced higher densities than the other rollers under consideration (sheep foot roller and pneumatic tyre roller).

INTRODUCTION

Compaction of soils is a planned and organized method for stabilizing soils and improving their performances by incorporating definite density and strength properties.

Number of investigations (Johnson, Sallberg, 1960, 1962) have solved certain aspects and conditions of compaction laboratory testing. Factors influencing compacted density such as, type of soil, water content, amount and method of compaction and admixtures were investigated. Furthermore, the effect of compaction on certain soil properties such as permeability and strength, stress-strain relationship were studied (Seed and Chan, 1959, Lambe, 1960).

The main object of this investigation is to study the comparative performance of three types of rollers used in compacting a calcarious fine sand. The rollers used included 8-ton smooth steel roller, sheep foot roller (taper feet) and pneumatic tyres roller. Most of tests were made on a layer loose soil 25.00cm thick, the moisture content of the soil being controlled at the optimum given by the standard proctor compaction test. The main problems investigated were:

- the relation between relative compaction and number of passes.
- the variation of relative compaction with depth.
- effect of rolling speed on the relative compaction.

SOIL PROPERTIES

The soil used in this study typical sand that cover great areas of west desert (Kilometer 21+00 to 22+00 of Alexandria - Matrouh road).

Series of tests were carried out on the fine portion passing sieve No. 40. Laboratory tests were carried out to determine the physical and chemical properties of fine sand.

Table 1. Physical Properties of Fine Sand

Liquid Limit (LL)	= 20.6
Plastic Limit (PL)	= 17.3
Plasticity Index(PI)	= 5.3
Classification of Soil according to AASHO	= A-3 (0.0)
Specific Gravity (G_m)	= 2.63
Maximum dry density (γ_{dm}), Ib/ft^3	= 114.27
Optimum Moisture content	= 10.7%

Table 2. Chemical Properties of Fine Sand

Ca	CO_2	Sio_2	AL_2O_3	MgO	Fe_2O_3	O.M	Other
52.6%	40.0%	3.13%	0.99%	0.18%	0.04%	0.22%	0.83%

TYPES OF ROLLER USED

The following three types of rollers were used during the investigation:

1. 8-ton smooth steel roller,
2. Sheep foot roller with tapered feet,
3. Pneumatic tyre roller.

The details of the dimensions and weights of the rollers are given in the following Tables:

Table 3. Dimensions and Weights of Rollers.

8-ton smooth steel roller

	size (in.)	weight (lb)	Load (lb/in. width)
Front wheel (one)	42" diam x 42"	7336	175
Rear wheel (two)	54" diam x 18"	9240	256

Sheep foot roller (Tapered feet)

Weight (empty)	6116 lb
Weight (full of water)	9586 lb
Number of Drums	2
Number of feet on drum	88
Number of feet on raw	4
Distance betweeen centers	12 in.
Size of feet	2.25"x2.25"
Ground pressure (empty)	145 lb/in^2
Ground Pressure (full with water)	228 Ib/in^2
Overall length	9 ' 7"

Pneumatic tyred roller

Weight (empty)	3920 lbs
Weight (full)	15680 lbs
Tyre size	7.5"x10.5"
Number of wheels	9 (4 front, 5 rear)
Spacing between wheels	10.5"
Overall width	4 ' 0"
Pressure under tyres	45 lb/in^2

TEST PROCEDURE

The tests were made on a level area of ground about 30.00m by 500.00m. Soil from adjacent borrow pit was excavated from 0.5 to 1.00m deep and placed on the test area to from the fill whose compacted thickness amounted to about 0.25m. The spreading of the fill was carried out in a systematic manner so that all areas received on equal amount of compaction from the tractor and scraper. The following procedures were performed:

1. The ground of borrow pit was first broken up with a rigid-tine cultivator and a 24in. disc-harrow. This was continued until the soil was loose and the then overplayed on the tested area.
2. Particular care was taken in the initial preparation of the soil as the loose condition represented the datum from which all increases in density due to the rollers were to be measured.
3. When the soil had been broken up, the moisture content was adjusted to the optimum given by the standard test. This was performed either by spraying with water or allowing to dry out by evaporation according to circumstances.
4. The ground was disc-harrowed again in order to obtain uniformity of moisture content throughout the fill and was then ready for rolling.
5. The rolling was carried out on parallel sections, progression being applied to each successive section. The smallest number of passes used varied with the type of roller, but the maximum number of passes was in general 32.
6. After the completion of the rolling, the density of the ground was determined using the coring equipment described below.In general, 30 independent tests were made for each individual number od passes.
7. The ground was then broken up and brought to the required moisture content again as described above, and the investigation repeated with other equipment.

MEASURING OF SOIL DENSITIES AND CALCULATION OF RELATIVE COMPACTION

The effectiveness of the rollers was determined by comparing the field dry density (γ_{df}) of compacted fill with dry density (γ_{dm})as determined by the standard compaction test.

The field density of the compaction fill was determined by the corecutter method. The apparatus consist of a steel cylinder 8.00 in long with an internal diameter of 6.00 in. The cylinder is bevelled at one end to produce a cutting edge to facilitate driving into the fill with a tool similar to punner, consisting of a heavy cylindrical weight attached to a length of steel tube. A steel dolly fits over the blunt end of the cutter to prevent its distortion and to enable it to be driven into the ground below the surface.

In the case of ground rolled with the smooth steel or pneumatic tyred rollers, cores were cut from the ground as finished by the roller. In the case of sheep foot roller, the overlaying loose was cleared away, and the cutter driven into the hard surface beneath.

After the cutter had been driven into the ground, it was dug out by means of a pick and spade. The protruding soil was then trimmed away flush with the ends and the weight of the enclosed in the cylinder determined. The moisture content of soil was obtained by drying in usual way a 50-gm sample taken the thoroughly mixed soil extruded from the cutter. Knowing the moisture content, the dry weight of soil in the cylinder was calculated. The volume of the cylindrical cutter was known, and hence the density of the soil was determined.

The relative compaction (R.C) of the soil was calculated from the formula:

$$R.C(\%) = \frac{\gamma_{df}}{\gamma_{dm}} \times 100$$

The maximum dry density (γ_{dm}) of the soil was 114.27lb/ft^3.

RESULTS AND DISCUSSION

The dry densities and relative compaction after each number of passes for different used rollers were determined. The results of these tests and calculations are shown in the following.

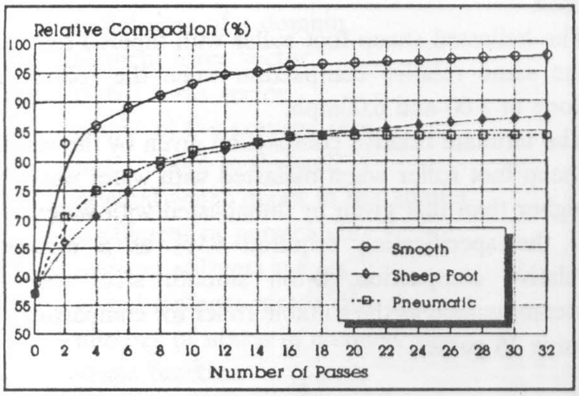

Figure 1. Relation between relative compaction and number of passes for different types of rollers

1. *Compaction of Rollers*

The results of compaction on calcarious fine sand using various type of rollers for different number of presented in Table (4). Curves showing the relation between relative compaction and number of passes for the rollers tested are given in Figure (1).

Table 4. Average dry densities and relative compaction after various number of passes different types of rollers.

Number of passes	Smooth steel roller		Sheep foot roller		Pneumatic tyre roller	
	γ_d f(lb/ft^3)	R.C (%)	γ_d f(lb/ft^3)	R.C (%)	γ_d f(lb/ft^3)	R.C (%)
0	67.30	58.9	67.30	58.9	67.30	58.9
1	88.20	77.2	71.99	63.0	75.42	66.0
2	94.84	83.0	76.10	66.6	80.10	70.1
4	98.04	85.8	80.45	70.4	85.25	74.6
8	102.39	89.6	89.36	78.2	91.42	80.0
16	110.16	96.4	95.96	83.7	93.70	82.0
32	108.79	99.3	99.30	86.9	93.93	82.2

It could be noticed that foe smooth & pneumatic rollers the relative compaction of calcarious fine sand increased rapidly during the first 10 passes, then increased at slow rate as the number of passes increased until finally no further increase in compaction obtained. For instance, the relative compaction was increased form original value 58.9% to 77.2% after one pass of smooth steel roller and to 85.8% after 4 passes.

On the other hand, for any number of passes up to 32, the smooth steel roller produced higher densities than the other roller. For instance, after 16 passes, the relative compaction determined after using smooth steel roller was 96.4% where 86.9% and 82.2% for the fine sand compacted by sheep foot roller and pneumatic tire roller respectively.

2. *Effect of Depth on Relative Compaction*

A comparison between densities with the dept was made for calcarious fine sand which had been subjected to 16 passes by each of the rollers used. The curves relating compaction with dept are shown in Figure (2).

The curves indicate that for all rollers used in this study, the relative compaction decreases with depth at varying rates depending on the types of rollers used. At a depth of 2in., relative compaction decreases from 100% to 94.2%, 93.0% and 91.1% for sheep foot roller, smooth steel roller and pneumatic tyre roller respectively.

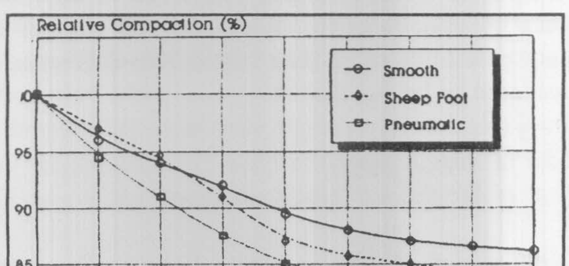

Figure 2. Variation in relative compaction with depth given by various rollers

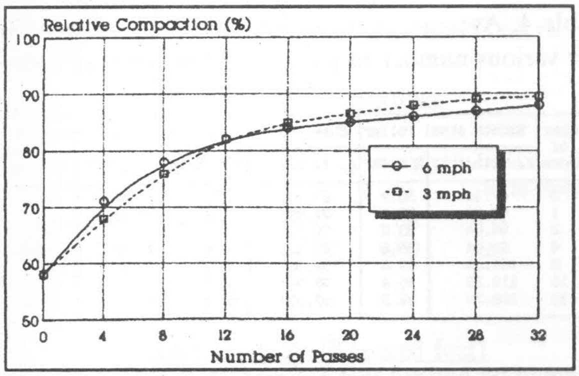

Figure 3. Effect of speed on compacting fine sand with tapered sheep foot roller

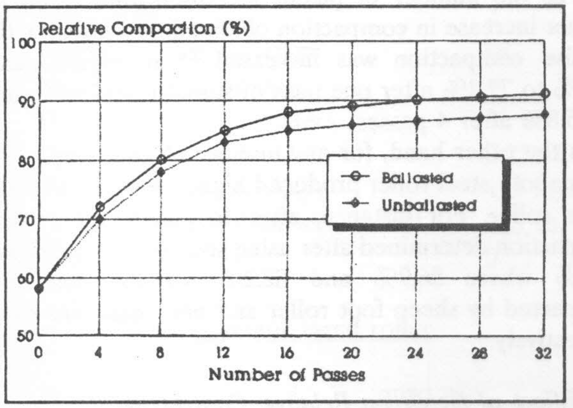

Figure 4. Comparison of the compaction of fine sand by sheep foot roller, unballasted and ballasted with water

3. Effect of Rolling Speed on Relative Compaction

The effect of the speed of rolling on compaction was investigated in the case of the tapered sheep-foot roller ballasted with water. Rolling was done at two speed 3.00 and 6.00mph. Referring to Figure (3), it will be seen that the curves between reactive compaction and number of passes not deviate by more than 1.00% This difference is not considered to be significient.

4. Effect of Weight on Relative Compaction

The effect of ballasting sheep-foot roller was investigated. Referring to Figure (4), ballasting the roller with water caused about 4% increase in relative compaction in the case of tapered sheep-foot roller.

CONCLUSION

A study has been made of the comparative performance of three types of rollers in compacting a calcarious fine sand which dominates in the great part of western desert. The compaction produced by an 8-ton smooth steel roller, a pneumatic tyred roller and tapered sheep foot roller has been studied. The procedure employed was to measure the density of the soil after various numbers of passes. The major findings and conclusions of this research are summarized as follows:

1- For any number of passes up to 32, the 8-ton smooth steel roller produced higher densities than the other two rollers under consideration.
2- No further increase in density took place after 16 passes with the 8-ton smooth roller or with pneumatic tyre roller did too.
3- The soil densities produced by the sheep foot roller were still increasing at 32 passes.
4- The relative compaction of the fill at the surface was considered to be 100% when rolled 16 times by any of the rollers used. The density, however, decreased with depth at varying rates, depending on the type of roller used.
5- The ballasted sheep foot roller with tapered feet gave the same relative compaction when the rolling was done at 3.00 and 6.00mph.
6- The ultimate relative compaction given by the tapered sheep foot roller when ballasted with water was 4.0% higher than that given by unballasted with water.
7- If the specification required 95% as a minimum relative compaction, 8-ton smooth steel roller is recommended as the suitable roller for compacting soil using 16 passes.

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