DETERMINATION OF ROLLER'S COMPACTED MATERIALS IN THE FIELD

Khalil Ahmed Abou-Ahmed
Department of Transportation Engineering
Faculty of Engineering, Alexandria University
Alexandria, Egypt

ABSTRACT

A nomogram is presented for evaluating the quantity of compacted materials for a certain filed work. The nomogram is simple in use and can be used for all types of rollers, since it requires only simple data such as roller's width, roller's velocity and number of required passes.
The aim of this study is to help the highway engineer to select the suitable type and number of rollers, which are required to finish a filed work in a specific time.

INTRODUCTION

In fact, the good selection of the roller's type leads to economic cost as well as high quality of compaction. The choice of the suitable roller is not so easy task, since there are several factors governing the soil compaction, such as the physical and mechanical properties of these soils in addition to the continuous progress and the development in the filed of roller's industry. The selection of rollers type depends mainly upon the type and quantity of compacted materials. The suitable and acceptable choice of compactor which achieves the specified degree of compaction in a reasonable time and with a minimum cost, is considered to be the vital factor in this filed. It is necessary, therefore, to predict the quantity of compacted materials in the filed by using different types of compactors. Such prediction facilitates the comparison process between the rollers performances and helps to select the suitable type of roller.

The aim of this paper is to present a nomogram from which the quantity of roller compacted materials is calculated.

The following are the main characteristics of the rollers which influence their compacting performances.

COMPACTION EFFECT

The different types of rollers are classified as static or dynamic rollers according to the nature of their compaction effects.

Compaction Due To The Effect of Static Force

The soil can be compacted by applying pure static load when the produced shear stresses overcome its shearing resistance. This means that the soil passed or changed from the elastic to the plastic state.

The fine grained soils generally consist of lumps and clods in loose state containing a high percent of air voids. The static compaction is used successfully for compacting these types of soils resulting in a decrease in the air void and pressing the particles together. However, the expulsion of pore water is not possible by the effect of short duration of static loading and a high static loading may cause shear failure.

The principal characteristics which effect the performance of the static effect rollers are: the load per unit width under the wheel, the ratio between the width and diameter of the wheel (as in case of smooth steel rollers), the contact pressure applied by each foot (in case of sheepsfoot rollers) and the tyre inflation pressure and the load carried by each tyre (as in case of pneumatic tyred rollers).

Experimental research has been conducted by Theiner [1] to study the performance of static rollers on 30 cm layer of sandy soil indicated the following:

a) For each roller's diameter the maximum density value can be reached by definite roller's weight, Figure.(1).
b) The plastic filed, in which the compaction process takes place decreased with the decrease of the load per unit width of the roller.
c) The study indicated that, high static loads cause shear failures, whereas big rollers diameter prevents or minimize it.

Compaction Due To The Effect Of Dynamic Force

The principle of dynamic or vibrating compaction is to reduce or to overcome the internal friction between the soil particles by rotating them continually until they slip

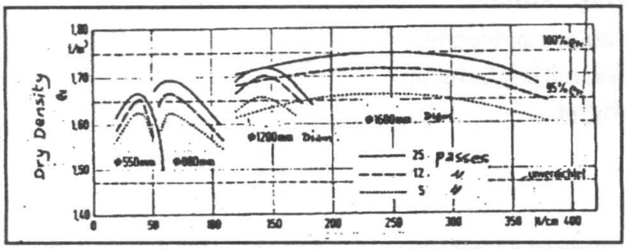

Figure 1. Compaction results of 30 cm layer of sandy soil with different types of rollers.

over each other and fall into whatever gaps are available between particles and so a compacted mass is obtained. Rollers of dynamic effect are most suitable when compacting purely coarse grained soils, whereas the static effect rollers are suitable when compacting soils containing significant amount of silt and clay.

Static effect rollers can be equiped with vibrating units. These vibrating units increase the produced pressure under the rollers. According to Lewis [2] the maximum measured pressure under the center line of the vibrating roll was double the pressure produced by the same roll when not vibrating Figure. (2).

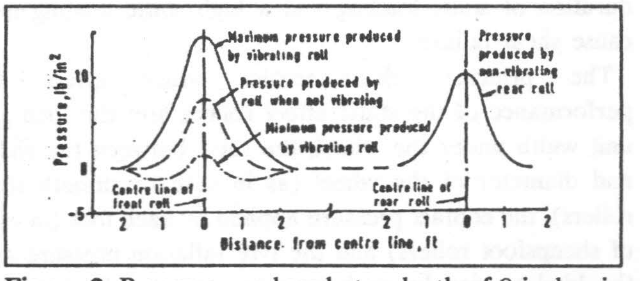

Figure 2. Pressure produced at a depth of 8 inches in a silty clay soil by a 2.5 ton vibrating roller.

Another important advantage of the vibrating unit is to increase the effective compaction depth. Figure. (3) shows a qualitative diagrams for comparison between the density obtained with static and dynamic compaction means in relation to the effective compaction depth [3].

Table (1) shows also a comparison between various types of compactors referring to their suitability for compacting various types of soil, layer thickness and required number of passes [4].

DETERMINATION OF ROLLERS COMPACTED MATERIALS

Generally the quantity of roller's compacted materials may be determined as the compacted area or the compacted volume. The compacted area per hour can be determined as follows:

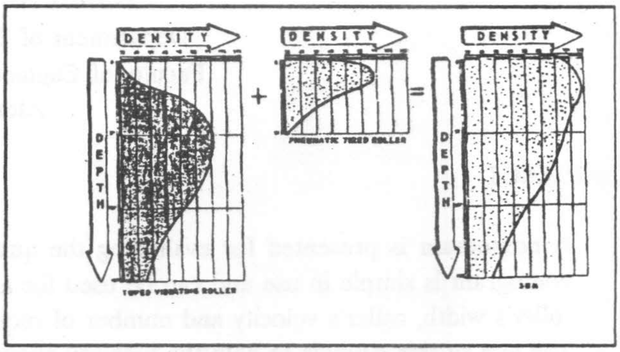

Figure 3. Qualitative diagrams of the density obtained with various compaction means in relation to the depth.

Table 1. Comparison between some various type of rollers [4].

	Type of Roller	Coarse Soils such as Sand & Gravel			Fine Soils Silt & Clay with Sand			Mixed Soils (Coarse & Fine Soils)			Soft and broken Rocks.		
		S	H cm	N	S	H cm	N	S	H cm	N	S	H cm	N
Static	Smooth Steel Roller	0	10-20	4-6	0	10-20	4-8	0	10-20	4-8			
	Sheepsfoot Roller				+	20-30	8-12	0	20-30	8-12	0	20-30	8-12
	Pneumatic tired (1)	+	20-30	6-10	+	20-30	6-10	0	20-30	6-10			
	Pneumatic tired (2)	+	30-50	6-10	+	30-40	6-10	+	30-40	6-10			
	Girdle Roller				+	20-30	6-8	+	20-30	6-8			
	Grating Roller				0	20-30	6-10	+	20-30	6-10	0	30-40	6-12
Dynamic	Drop Plate Rammer				0	50-70	2-4	+	50-70	2-4	+	50-80	2-4
	Explosion's Rammer	0	20-50	3-5	+	20-40	3-5	0	20-50	3-5	0	50-90	3-5
	Fast Blow Rammer	0	20-40	2-4	0	10-20	2-4	0	20-30	2-4			
	Towed Vibr. < 5 Hp	+	30-50	3-5				0	20-40	3-5			
	Towed Vibr. 5-8 Hp	+	40-60	3-5	0	20-30	3-4	+	30-50	3-5	0	40-60	4-6
	Towed Vibr. > 8 Hp	+	50-80	3-5	0	30-40	3-4	+	40-60	3-5	+	50-95	4-6
	Duplex < 2.5 Hp	+	20-40	4-6	0	10-20	3-8	0	20-30	5-8	0	30-50	5-8
	Duplex > 2.5 Hp	+	30-50	4-6	0	10-30	5-8	+	20-40	5-8			
	Tandem Vibr. < 5 Hp	+	20-40	4-6				0	20-40	5-8			
	Tandem Vibr. > 5 Hp	+	30-50	4-6									
	Vibr. Sheepsfoot Roller	0	30-50	3-5	+	20-40	6-10	+	20-40	6-10	+	30-50	6-10
	Vibr. Plate < 2 Hp	+	20-40	5-8				0	10-20	5-8			
	Vibr. Plate > 2 Hp	+	30-60	4-6	0	20-30	6-8	0	20-40	4-6	0	30-50	4-6

0 = Suitable , + = more Suitable
1 = Self-Propelled, 2 = Towed Roller

$$A_c = 1000\ B.V \qquad (1)$$

where A_c = the compacted area in square meter per hour (m^2/h)

B = roller's width in meter (m)

V = the roller's velocity in kilometer/hour (km/h)

Equation (1) can be used only by one pass of roller. for more than that equation (1) should be modified as follows:

$$Ac = \frac{1000\ B.v}{N} \qquad (2)$$

where N = the number of roller's passes
V = the roller's velocity in (Km?h)
B = the roller's width in (meter)

The roller's width B may be reduced by about 10 % to take into consideration the reduction of the compacted width due to the overlaps between the roller's passes.

The use of equation (2) based on the following assumptions:

a. The roller's velocity is uniform
b. There are no interruptions during the compaction in the filed. Such interruptions can be due to the roller's defect, unsuitable weather and any filed troubles.

Therefore equation (2) should be modified to take into consideration the above mentioned factors which affect the rollers filed compaction. The modification is carried out by multiplying equation (2) by the factors η_1, η_2 and η_3 which represent the effect of unsuitable filed work conditions due to roller's performance, weather and filed troubles respectively as follows:

$$A_c = \frac{1000\ B.V.\eta_1\ \eta_2\ \eta_3}{N} \qquad (3)$$

For simplicity the factors η_1, η_2 and η_3 can be expressed as one factor η_t, which is the sum of the multiplication of them. This factor η will be named in this paper as filed factor. By introducing the filed factor η_t instead of η_1, η_2 and η_2 in equation (3) it takes the following from:

$$A_c = \frac{1000\ B.V.\ \eta_t}{N} \qquad (4)$$

where η_t = filed factor which represents the various filed factors. The maximum value of η_t is 100 % by compaction conditions and varies from 80 % in good conditions to 40 % in bad conditions [1]. In any case the estimation of the filed factor η_t requires a good experience from the highway engineer who can easily and precisely predict a right value for the expected filed compaction conditions. From the previous discussions it is clear that, the filed factor has no definite value and it can be changed from time to time at the same compaction site. For this reason the value of η_t was taken 100 % in equation (4) and the solution of this equation for different values of B,V and N is presented in Figure (4).

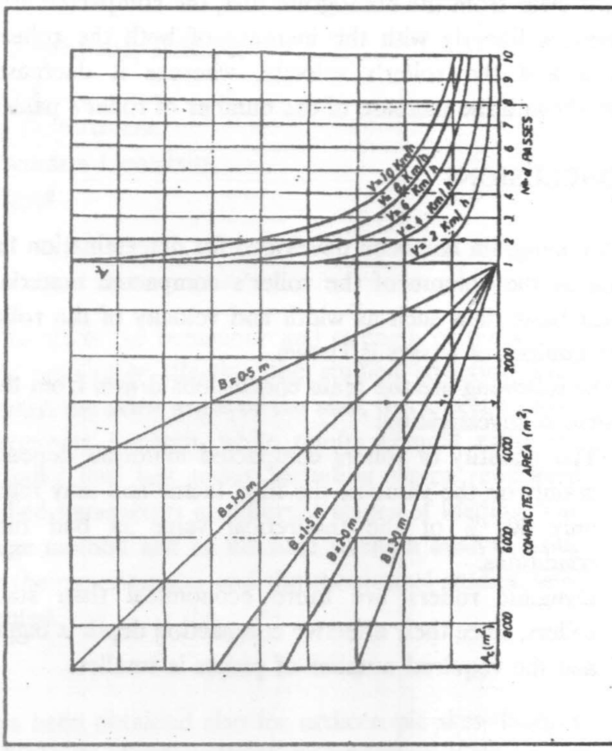

Figure 4. Nomogram for determination of rollers compacted area.

DEMONSTRATION OF THE NOMOGRAM

The nomogram can be divided into two parts. The right part represents the relation between the number of passes (N) as abscissa and the compacted area (A_c) as ordinate at different roller's velocities. The left part represents the relationship between the roller's width (B) and the compacted area A_c.

The nomogram gives the compacted area, and the compacted volume can be easily obtained by multiplying the determined compacted area by the leyer's compacted thickness.

The nomogram value can be named as theoretical or calculated value and to estimate the practical value or the nearly filed value, the theoretical value should be multiplied by the filed factor η_t.

DETERMINATION OF THE COMPACTED AREA FROM THE NOMOGRAM

From a given number of passes (N) vertical to the curve of velocity (V) and then horizontal to the line of the roller's width and done vertically, again, to get the value of compacted area.

It is clear from the nomogram that, the compacted area increases linearly with the increase of both the roller's width and the roller's velocity, whereas it decreases linearly with the increase of the number of roller's passes.

CONCLUSIONS

A nomogram has been developed for determination the area or the volume of the roller's compacted materials when basic data such as width and velocity of the roller and number of passes is known.

The following are the main conclusions drawn from this course of investigation:

1. The quantity of rollers compacted materials depends mainly on the value of the filed factor and may reach only 40 % of the theoretical value in bad filed conditions.
2. Dynamic rollers are more economical than static rollers, since their effective compaction depth is bigger and the required number of passes is smaller.
3. The quantity of compacted material increases linearly with the increases of roller's width and roller's velocity and with the decrease of number of passes.

REFERENCES

[1] Wehner, B./ Siedek, P./Schulzed, K.-H: Handbuch des Strassenbaus. B and 2, Baustoffe, Bauweisen, Baudurch fuhrung, Springer Verlag, Berlin, Heidelberg, 1977.

[2] O, Flaherty, C. A.: Highways, Edward Arnold (Publishers) Ltd. London, First Published, 1967.

[3] Simers VIA Capecelatro 10, Milano Domenighett, DSM-Mi-31651.

[4] Der-Elsner, Handbuch fuer Strassenbau-und Straβenverkerstechnik Erich Schmidt verlag, Berlin, Bielefeld, Muenchen, 1985.