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Determination of compacting parameters of dispersed rocks

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Abstract. Ground beddings are used to eliminate the subsidence during the construction of buildings, facilities, earthfills on the subsiding soils. The most cost-effective are the ground beddings made of local material, i.e. the subsiding soil. An effective way of soil deposing is the cyclic load created by the rollers, dies, and tampers. The paper presents the results of study devoted to the compacting of subsidence loams of cyclic load.

1. Introduction

Subsiding soils are widespread in the Belgorod Region and Belgorod City. The thickness of the subsidence soil is usually low and amounts to 3 ... 5 m; therefore, most construction sites refer to the 1st type of subsidence. With the foundation depth of buildings and constructions of 1.5 ... 2.5 m the thickness of the subsidence zone is only 2 ... 3 m. Under these conditions it is viable to replace the subsiding soil with another type of soil or to change its building properties. Deformations of engineering constructions on the ground beddings are insignificant and rather even compared to the object that had been built on the natural subsiding loams [1 ... 3]. As is well known the subsiding soils change their physical and mechanical properties followed by compaction due to the unstable structure and under the influence of humidity. [1] As the results of studies show an effective and affordable method is the compaction of soils both natural and filled during the construction of ground beddings.

Usually during the construction of foundations and earthfills the optimal density and humidity are determined in the laboratory applying the method of standard compaction (according to the Proctor). Often, the preliminary values of density and humidity significantly differ from the actual values obtained when compacting the soil with rollers. This can be explained by the fact that during the rolling the compacting load is applied in a cyclic manner in conditions of possible lateral expansion of soil. In this case, the cyclic load parameters depend on the type of soil compacting machine and the rolling mode. On the standard compaction device the soil is compacted by blows of weight of a certain weight in a rigid cup, which excludes the possibility of lateral expansion.

2. Materials and methods

Several laboratory tests were performed to determine the parameters of cyclic load (its maximum value in conditions of soil lateral expansion) on the soil compactability.

The most typical soil for the Central and Southern Regions of Russia, which is the loess-like loam was tested in its remolded state (without grinding); however, with the preservation of individual natural structures in separate lumps and aggregates. The initial moisture content of the compacted soil

varied from 16 to 28%. The characteristics of loam were as follows: liquid limit was $W_1 = 32\%$, rolling out was $W_p = 18\%$, porosity coefficient in the natural state was $e = 0.96$.

The maximum value of cyclic load was 2, 4, 6 and 8 kp/cm_2. To make the process more simple a linear dependence of velocity change of stress state with the time equal to 1 kp/cm_2 per 1 s was adopted. The unloading followed immediately after loading. The time interval between cyclic loads was 12 minutes. For each humidity value 10 compacting and unloading cycles were performed.

3. Main part

Fig. 1 shows the diagrams of soil density dependence on the humidity at different compacting loads. It has been established that by the increase in the moisture content the soil density increases to a definite maximum value depending on the load. With the increase in the load from 2 to 8.0 kg/cm_2 the optimum density of dry soil increases from 1.42 to 1.65 gcm^3, respectively, and the optimum moisture content decreases from 30 to 21%. It was also established that while the soil moisture is less or equal to the optimal moisture level for a given maximum value of the cyclic load, the compaction takes place without any noticeable lateral expansion of the soil volume, which indicates that under these conditions the strength of the soil does not decrease. It has been established that with the increase in humidity by 1.0-4.0% (depending on the value of the compacting load) there is a loss of the bearing capacity of the soil, which is expressed in the soil breaking from under the die.
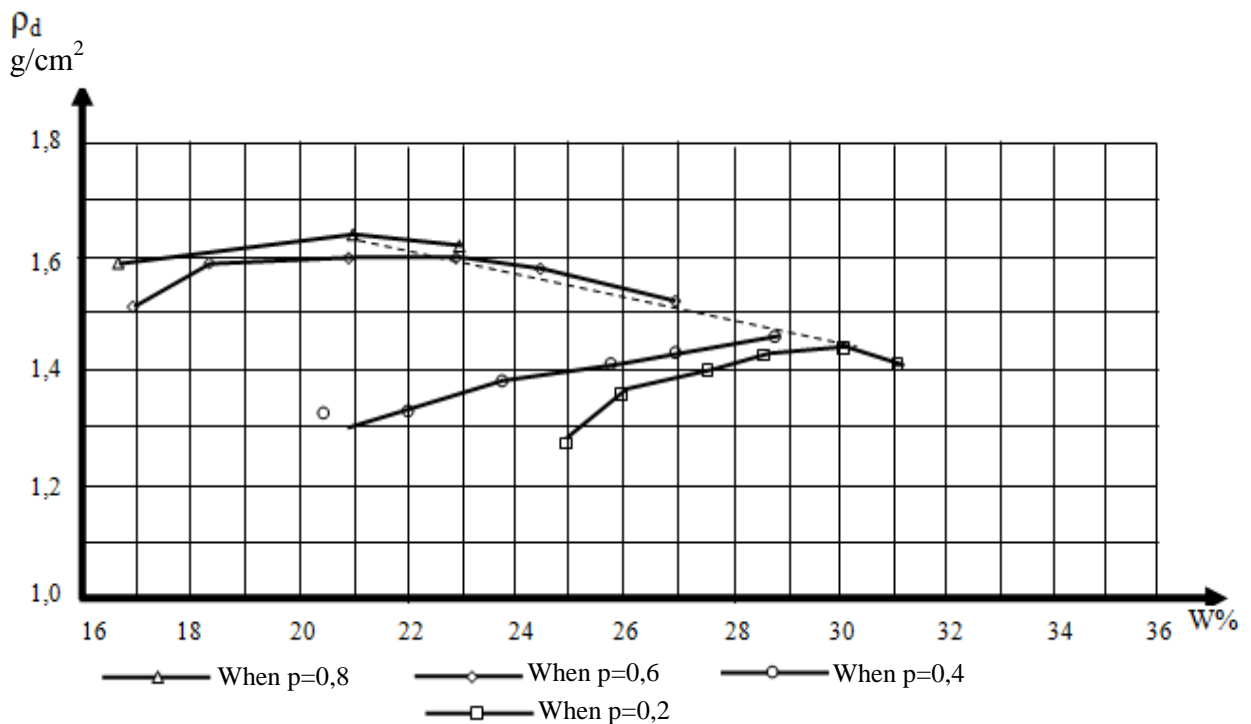

Figure 1. Soil density dependence on humidity at different compacting loads (after 10 cycles of loading)

The tangent line to the dependence diagram of density on humidity (Fig. 1) corresponds to the limit values of humidity. In case these values are above the indicated limit the soil loses its load bearing capacity. The table shows the limit values of soil density and humidity for various compaction loads, as well as the degree of saturation (moisture degree).

Table 1. Density and humidity limit values at various compacting loads

Load,	Limit values		

P mPa	humidity, %	dry density of soil, ρ_{dg}/cm^3	degree of saturation
2	30.1	1.43	0.91
4	28.7	1.45	0.89
6	23	1.59	0.88
8	21	1.65	0.88

The studies made it possible to establish that the optimum conditions correspond to a combination of load and humidity at which the compacted soil acquires a monolithic structure with considerable strength (without visible macropores and structural elements, i.e. clumps). The smaller the value of the compacting load, the greater the moisture content of the compacted soil to achieve a monolithic structure.

The monolithic structure is also obtained with the humidity exceeding the optimum level for a given load; however, the soil loses its bearing capacity.

The study was carried out in the laboratory conditions for compaction of soil with cyclic loads under specified parameters and conditions of possible lateral expansion of the soil, which allows to pre-select the type of soil compacting mechanism in relation to the specific conditions for the erection of earthfills or determine the optimum value of soil density and humidity for the selected type of soil compacting machine and the rolling mode (i.e. under specified cyclic load parameters). When the compacting is standard, this is not possible because the working conditions of the soil compacting mechanism cannot be simulated.
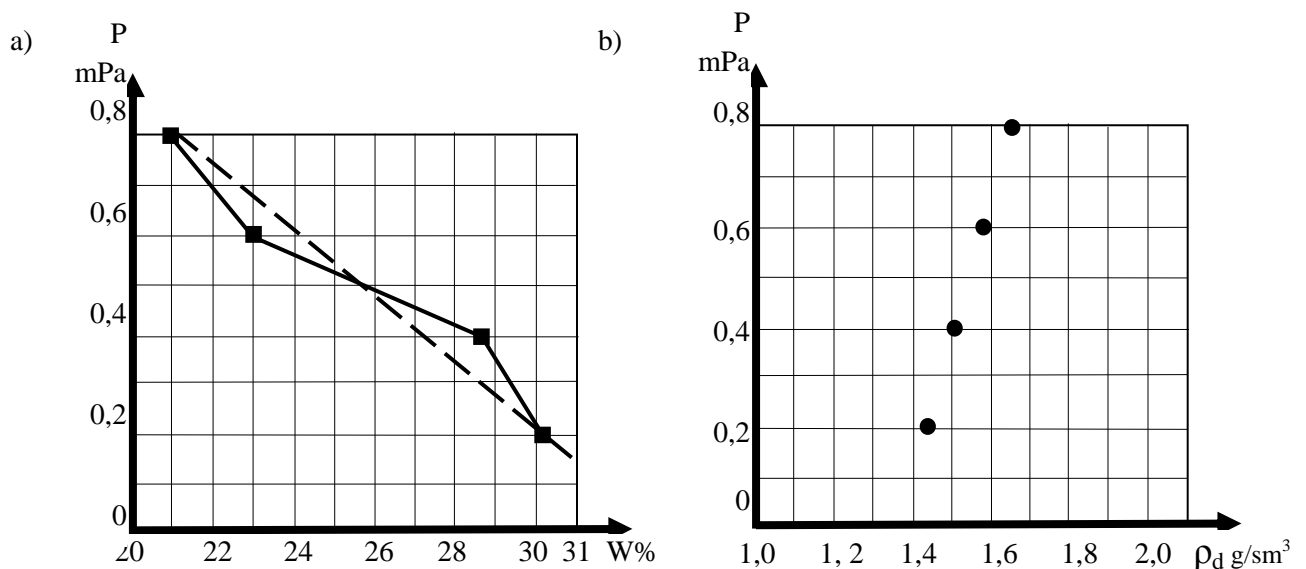

Figure 2. Dependences of the optimum values of soil density and moisture from the compacting load: a) moisture - load b) density – load

Fig. 2 shows the dependence diagrams of the optimum values of moisture and soil density on the compacting load. It can be seen from the diagram that the optimum values of density (ρ_d) and humidity (W) depend significantly on the value of the compacting load. The study made it possible to establish that the optimum conditions correspond to a combination of the load and humidity at which the compacted soil acquires a monolithic structure with considerable strength (without visible macropores

and structural elements, i.e. clumps). The smaller the value of the compacting load, the greater the moisture content of the compacted soil to achieve a monolithic structure. The monolithic structure is also obtained with the humidity exceeding the optimum level for a given load; however, the soil loses its bearing capacity.

4. Conclusion
The study was carried out in the laboratory conditions for compaction of soil with cyclic loads under specified parameters and conditions of possible lateral expansion of the soil, which allows to pre-select the type of soil compacting mechanism in relation to the specific conditions for the erection of earthfills or determine the optimum value of soil density and humidity for the selected type of soil compacting machine and the rolling mode (i.e. under specified cyclic load parameters). When the compacting is standard, this is not possible because the working conditions of the soil compacting mechanism cannot be simulated.

5. Acknowledgement

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