CONSTRUCTION UNDER SPECIAL SOIL CONDITIONS

COLLAPSIBLE-SOIL COMPACTION BY 80-TON MASS RAMMER

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One of the most economical methods of preparation of collapsible soil bases is compaction by heavy rammers 3-7 tons in mass, dropped from heights of 3-8 m by means of excavator cranes [1]. The compacted layer thickness (Pd ≥ 1.6 tons/m³) is 1-2.5 m, which is sufficient in most cases for construction on Type I collapsibility soils. At sites with Type II collapsibility soil conditions, surface compaction makes it possible to partially or fully eliminate the soil collapse only for the foundation loads and may be applied in combination with protection against water and other constructional measures, compaction by means of earth piles, and elimination of collapse by preliminary soaking.

Using a 15-ton mass rammer dropped from a height of 10 m to compact fill soils consisting of morainic loams, the VNIIOSP Institute obtained compaction depth of 5-7 m at the construction site of the Zagorsk pumped-storage plant [2].

In order to compact a six-meter thick soil base layer consisting mainly of sands which contained a clay fraction, the Scientific-Research Department of the Gidroproekt Institute used a 25-ton rammer dropped from a height of 20-25 m [3].

Use by the VNIIOSP Institute of a 24-ton mass rammer dropped from a height of 10 m to compact collapsible soils made it possible to obtain a 4-4.5 m compacted zone.

To construct compacted beds, a new tamping technique is also applied [4], in which for a 10-15 ton rammer mass the total bed thickness may reach 8-14 m, the modulus of deformation of the compacted soil being 20-22 MPa.

In order to increase the thickness of the compacted beds and to investigate the vibration propagation and the compaction depths, the Ministry of Construction of the Moldavian SSR made an experimental installation for compacting soils by means of an 80-ton mass rammer. It consists (Fig. 1) of a rammer of square section 16 m² in area (4 × 4 m) and of a lifting cross-arm whose ends are secured to the hooks of two Class TG-502 pipelayers 50 tons in capacity each. The height of fall of the rammer was 6.8 m.

The test site is located in the area of a personal computer factory under construction in the northeast part of Kishnev and is covered by soils of the Quaternary period, consisting of detrital-deluvial loams to a depth of 10-11 m, clays, sands, and also neogene deposits. Groundwater occurs at depths of 15.8-17.7 m. The loams have collapsibility properties to a depth of 8-9 m under additional loading.

The physico-mechanical properties of the loams in the natural state are as follows: natural water content w = 0.12-0.14, plastic limit Wp = 0.16-0.17, liquid limit wL = 0.28-0.30, plasticity index Ip = 0.12, density at natural water content ρ = 1.70-1.73 tons/m³, dry density Pd = 1.50-1.56 tons/m³, cohesion c = 0.018 MPa, and angle of internal friction φ = 21°. The modulus of deformation at natural water content is E = 9.5 MPa, and at full water saturation it is Esat = 8 MPa.

In the tests, the sinking of the rammer in each blow was determined and the amplitudes and velocities of the horizontal vibrations of ground surface points were measured. After the tests, static sounding of the base to a depth of 10 m was carried out by the radioisotope method, and the physical characteristics of the soils were determined. The measured depth of the zone of sufficient compaction was 5-5.5 m.

To determine the amplitude and velocities of the soil vibrations, use was made of a set of instruments which included vibrogauges of Types VBP-3, VBPP (large-displacement vibrographs), and VEGIK (vibrogauges with a limit of allowable recorded amplitudes of up to 1 mm).


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The vibrogaug e signals were sent to Types MO02 and MO14 galvanometers installed in N115 light-beam oscillographs. Calibration of the recording channels was performed before the start and after the end of the work stages, which was determined by the complex conditions under which the recording system operated. The required sensitivity factors of the recording channels were selected directly at the test site for trial heights of fall of the rammer. The recording instruments were installed along a 175 m long profile from the center of compaction.

During the compaction process, the ground surface vibration amplitudes were recorded for a 2-6.8 m height of fall of the rammer.

Figure 2 shows the relation between the sinking $S$ of the rammer, dropped from a height of 5.3 m, and the number of blows $n$, and between the last-mentioned quantity and the soil bulging-out $H$, measured at a distance of 1.0 m from the edge of the trench formed by sinking the rammer. For a total sinking of 130-150 cm, the mean sinking per rammer blow was 5.8-8.2 cm, and for the last three blows it was 3.3-5 cm. The soil bulging-out was 15-40 cm. The