Over the last decades, emergency situations in construction on loess soils have substantially decreased, despite a significant increase in water consumption and especially in hot-water supply to built-up areas. This is evidently due to massive use of pile foundations in construction of structures and multistory buildings, and also to increase in the rigidity and strength of their superstructures. For this reason it is difficult to agree with the concepts of M. N. Gol'dshtein [1] about participation of hazardous collapse deformations of the structures.

Discussion about how to construct on loess in the Soviet Union have been going on since the beginning of the first five-year plane. They were especially significant in 1983 in connection with inadmissible settlements and tilts of several multistory buildings in Volgodonsk, Rostov Region, constructed on shallow mat foundations. However, it seems to us that until the present time these deformations and their causes have been insufficiently studied in the literature. At the same time, despite significantly smaller settlements of buildings on pile foundations, during the last few years a large number of conflicting works have been published which consider the effect of negative friction forces on the lateral surfaces of piles and of rise of the groundwater level (GWL) on the settlement of structures [2-4, 7-9].

In 1982, two nine-story residential large-panel buildings of Series 96, of the same type, were commissioned, whose soil base was a 20 m thick mass classified under Type II collapsibility soil conditions. The building foundations consisted of crossed reinforced concrete cast-in-place strips resting on a compacted soil layer up to 3 m thick. After nearly one year of operation, these buildings presented inadmissible settlements and tilts (Fig. 1).

These diagrams were constructed from settlement observation data for the period from 13 May 1982 to 15 February 1983, that is, for ten months. The building sections became inclined toward each other as a result of concentrated soaking of the building base soils in the direction from top to bottom, from sources located at the places of the largest settlements (defective water-carrying pipelines). As can be seen from Fig. 1, the maximum settlements, equal to 66 and 65 cm, occurred in the adjacent sections of the building sections; for the entire period, the settlements exceeded 80 cm, and the tilt reached 0.009. The settlements and tilts of the sections took place without affecting the strength of their main components. However, because of the fact that in the longitudinal direction the sections were tilting toward each other, at the top they showed close contact and the possibility of damage of the structures arose. In March 1989, the lodgers of one of the building sections were evacuated. A similar situation arose in the other building section and made it necessary also to evacuate the lodgers. Inadmissible settlements and tilts occurred during the beginning of the eighties in other residential and public buildings in Volgodonsk [5]. The main cause was inadequacy of the anticollapse measures, which did not ensure elimination of the collapsibility within the limits of the entire deformable zone under the foundations. The lower limit of this zone for a minimal foundation dimension of 12 m in plan is at a depth of no less than 12 m, and the compacted layer under the foundations, even in the case of its high quality preparation, was sufficient for eliminating the collapsibility only to a depth of 3 m. Thus, under conditions of low-quality construction of the water-carrying pipelines and poor compaction of the soil layers under the foundations, collapse of the soils under the action of the external loads (weight of the buildings themselves) for soaking from the top took place rather quickly. The same opinion about the causes of inadmissible settlements of buildings on compacted layers is held also by Gol'dshtein [1].

The building settlements and tilts in Volgodonsk occurred evidently as a result of intense and prolonged soaking of the soils in the direction from top to bottom. As shown by the experience obtained from observations carried out over many years in Volgodonsk, quick
Fig. 1. Settlement diagrams for sections Nos. 1 and 2 of building No. 128. Section dimensions in m, settlements in mm.

rise of the GWL during several weeks by 5 m and more, as a result of emergency situations in the water systems, and subsequent GWL drop did not cause soil collapse or structure settlements. As a rule, over the entire city area the GWL rise rate did not exceed 1.0 m/yr, and only infrequently it reached 2 m/yr, the active period of development of differential settlements of the buildings and structures occurring approximately over the same period. Taking into account the comparatively low relative collapsibility of the soils at depths corresponding to the GWL (no more than 0.02), after two years the soil collapse caused by rise of the water from the bottom could not exceed 4 cm, which would not substantially affect the state of the buildings.

Let us consider now the situation with buildings and structures in Volgodonsk constructed on pile foundations, with the piles cutting fully through the collapsible mass. Instrumental observations on the settlements of buildings and structures on pile foundations, carried out over the 16 years which have elapsed since the start of construction of the Atommash plant, showed that prolonged soaking from the top causes settlements occurring nonuniformly with time. In several cases, after a short (1-2 months) initial period, over a 1-2 yr span there was an active period of development of structure settlements at a rate of 3 to 20 mm/month, with simultaneous increase in their nonuniformity from 0 to 0.006. The maximum settlements of the buildings and structures on pile foundations over the active development period did not exceed 22 cm. Subsequently, they developed more slowly at a rate of 1-2 cm per yr and were gradually attenuated. Taking into account the attenuation period, at the present time for the entire plant the settlements have reached 31 cm only in two columns, whereas in the other columns they are significantly smaller. During the attenuation period the settlements take place over a span of five years and more at a practically uniform rate and for this reason they are not dangerous for the structures. After attenuation, there is conventional stabilization of the settlements, the rate of which does not exceed 1.0 cm/yr.

It is interesting to compare the structure settlements with the soil collapse, which was systematically measured by the RostovDonTISIZ Institute by means of surface ground marks and deep marks. The observations showed that over the entire plant site and city area the surface and deep marks settled no more than 30 cm. This demonstrates that the settlements of buildings on shallow foundations in the city (of the order of 80 cm) are not connected with soil collapse under the dead weight action.

Groundwater level observations carried out by means of an especially developed system of piezometric holes showed that GWL rise takes place nonuniformly, with formation of mounds. The observations showed that over the entire plant site and city area the surface and deep marks settled no more than 30 cm. This demonstrates that the settlements of buildings on shallow foundations in the city (of the order of 80 cm) are not connected with soil collapse under the dead weight action.

Since the start of construction of the plant and until the present time the GWL has risen by 2-16 m, which corresponds to a depth of occurrence of 24-10 m from the ground surface. Where the GWL lies at lesser depths, the soil layers which are collapsible under the action of the dead weight of the mass are fully soaked.

In most cases, the maximum settlements of the structures coincide with the location of the mounds occurring as a result of intense soaking of the soils from the top rather than of water rise from the bottom. A comparison of the settlements of structures on pile foundations with the collapse of the soils under the action of their dead weight and the weight of the indicates the common nature of their development [7, 8].