Settlements of TV tower built on stabilized loess

Affaissements d'une tour de TV construite sur loess stabilisé

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SYNOPSIS The TV tower (h=190 m) in Rousse on the Danube was founded on 22 m thick layer of collapsable loess. The loess was compacted with a heavy tamper from the bottom of 12.5 m deep excavation after which a soil-cement cushion 4.5 m thick has been built. The foundation of the tower is round reinforced concrete slab with a diameter of 36 m. Calculated using different methods the foundation settlement ranges between 3.73 cm and 6.85 cm, while the geodetic measured settlement is 3.57 cm.

INTRODUCTION

The highest TV tower in Bulgaria (h=190 m) has been built in Rousse at the Danube on collapsable loess soil about 22 m thick. The excavation reached 12.5 m below the surface and its bottom has been compacted applying 7-ton tamper. Then a 4.5 m thick soil-cement cushion has been built. The foundation consists of a round reinforced concrete slab with a diameter of 36 m and 1.5 m thickness strenghtened with gills at its upper end which are 1.0 m tall at the edge and 3.5 m at the centre. The foundation of the tower has been described by Minkov et al.(1980). A comparison has now been presented of the calculated according to different methods and the geodetic-measured settlements during the construction of the tower.

CALCULATED SETTLEMENTS

Fig. 1 features the geometrical characteristics of the foundation and the soil base, as well as the thickness, modulus of total deformation and Poisson's ratio of the natural, compacted and stabilized loess. When calculating the settlements the fact that the uppermost layer has the highest rigidity $M_3/M_1=5,6$ and that its thickness Z is small compared to the diameter of the foundation /D/Z=8/ has been taken into consideration. The following methods have been used.

i Method of large-size foundation of the Soviet Building Code SNiP-II-15-74. It has been assumed that the soil base is subject to linear deforming and has limited thickness. The actual modulus of deformation of the individual layers is taken into account.

ii Method of Burmister, whose graph of settlements of two-layered soil foundation has been corrected by Karachorov (1984) on the basis of data obtained from tests with metallic plates.

iii Method of Kushner (1968) using the equivalent modulus of deformation of the soil base.

iiii Finite elements method for multilayer soil base of the STRUDL program of the Massachusetts Institute of Technology.

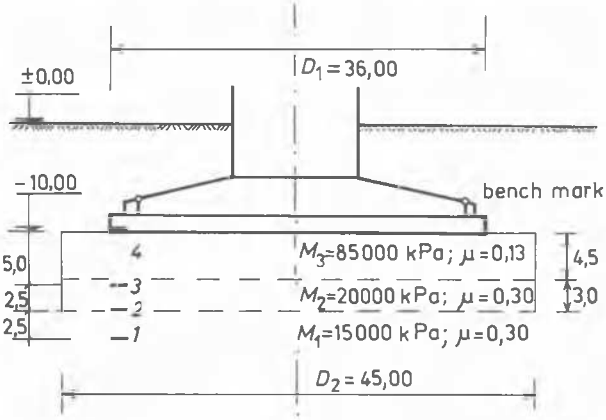

Fig.1.Scheme of the foundation

The settlements have been calculated for loadings attained after the conventional elevation +0.00 has been reached, after the construction of 1/4 of the tower and after its completion /Table 1/.
The differences of the settlements calculated according to the different methods range between 0.55 and 4.12 cm. For loading of 146 kPa, the greatest settlement of 6.85 cm has been obtained using the finite elements method, and the smallest - of 3.73 cm according to the SNiP-II-15-74 method. All methods have produced results within the admissible settlements of the tower.

TABLE 1
Calculated and measured settlements of the foundation of the tower

Load	Calculated settlements				Measured
	SNiP II-15-74	Corrected formula of Burmister	Kushner method	FEM	settlements
kPa	cm	cm	cm	cm	cm
146.0	3.73	6.75	4.78	6.85	3.57
98.1	2.50	6.62	3.40	-	2.98
60.5	1.55	4.02	2.10	-	1.84

MEASURED SETTLEMENTS

The settlement and tilting of the tower during construction have been measured with the assistance of a geodetic network consisting of 3 back pillars and two basic bore hole reference points of special design (Milev, 1984), leaning on practically uncollapsable layers at a depth of 25 m. Four symetrical reference points have been placed on the foundation while in the base there are 3 deep reference points reaching depths of 5, 7.5 and 10 m, i.e. the bottom of the soil-cement cushion and the compacted loess and the upper layer of the natural loess /Fig. 1/. The measurements have been taken over equal periods of time during the five years of construction with precision of up to 0.1 mm. The settlements of the foundation and the soil base have been uniform and have tended to die out. The mean settlement of the foundation has been 3.53 cm (Table 1): at a depth of 5 m - 3.23 cm, 7.5 m - 2.51 cm and 10 m - 2.13 cm. Two years after the completion of the tower the settlement of the foundation reached 4.5 cm.

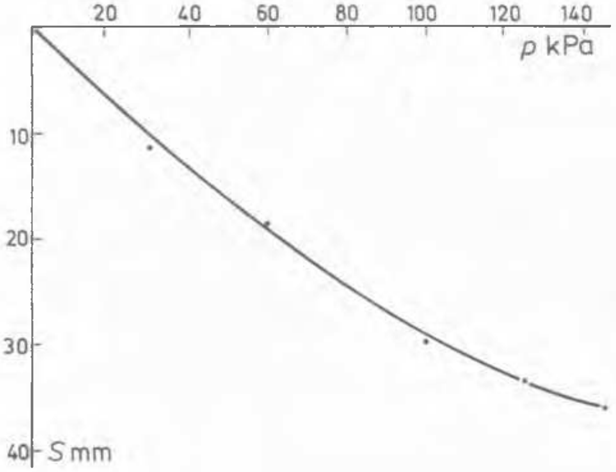

Fig.2. Loading-settlement relation of the reinforced concrete foundation of the tower

CONCLUSION

An analysis of the geodetic measurements has shown that during the period of construction the tower has undergone minor settlement which will die out in future if there is no change in the humidity regime of the foundation. The settlements calculated according to SNiP-II-74 correspond best to the measured settlements - the difference is less than 5%.

In this case the main purpose of the soil-cement cushion and the compacted layer under it is to replace the strongly collapsable loess located directly under the foundation. Besides, the cushion has an anti-seismic effect absorbing the big instantaneous additional stresses transmitted from the foundation during oscillations of the tower.

The geodetic measurements are to continue in future not only because of the valuable data on settlements under constant loading but also from the point of view of the exploitational security of the tower.

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