DEFORMATION OF AN APARTMENT BUILDING AS A RESULT OF THAWING OF THE BASE

G. M. Ulichkin, V. G. Mel'nik, and Yu. N. Baranov

The causes of deformations of structures as a consequence of freezing and thawing of the base have presently been studied and described sufficiently well, for example in [1, 2, 3, et al.]. However, the intense development of new industrial regions is sometimes accompanied by certain difficulties owing to the absence of construction experience in a given locale, unaccounted for regional soil conditions, incorrect determination of the depth of freezing and effect of heaving of the soils on the structures, etc.

Deserving of attention is the case that occurred in the city of Lisakovsk in the Kazakh SSR during construction of a five-story apartment building of series 1-439A-38 with walls of large lightweight concrete blocks.

The strip foundations of the buildings were composed of precast foundation blocks and slabs. The depth of the lower surface of the foundations of the extreme row (from the graded surface) was 1.6 m and of the middle row (from the surface of the basement floor) 0.9 m. A basement was located under the entire building.

The construction site was a plain composed of the following soils: 0.6-m-thick topsoil, then a 0.5-m-thick layer of stiff loam (density 2.7 tons/m³, water content 17%), and then 12.4-m-thick fine-grained saturated sand (density 2.8 tons/m³, water content 22.5%). The groundwaters in the form of a perched water table were at a depth of 3.5 m from the surface. The fine-grained saturated sand served as the base for the foundations.

Subsurface construction with backfilling of the foundations was completed in October. The superstructure of the building was assembled between November and February of the next year. Finishing works and installation of the heating system began in May, but owing to the appearance of through cracks in the supporting structures works on the building stopped.

Observation of the settlements of the buildings by means of 40 markers embedded in the walls of the first story and of opening of cracks was carried out, as a result of which it was established that the most intense sinking of the building occurred between May and September. The maximum rate of settlement reached 2.43 mm/day; the total settlement by the start of summer of the next year was 95 mm.

Figure 1 shows a graph of the maximum settlements in time, plotted from the data of observations of the displacements of the markers. It was not possible to take into account the settlement of the base before the start of observations in May. However, the disturbances of the continuity of the structures of the building that formed in the spring indicate a considerable magnitude and intensity of their occurrence. We see from Fig. 1 that by the start of winter the intensity of the settlements decreased, and by the start of summer of the next year the settlements had stabilized for the most part.

The settlements occurred extremely unevenly. The diagrams of settlements of the foundations at various periods of time along the longitudinal bearing wall of the extreme row of the building, presented in Fig. 2, show that the maximum difference of settlements was 40 mm.

The nonuniformity of the deformations of the bases and, consequently, of the structural elements increased with the course of time. Thus, if the relative deflection in the portion of the longitudinal wall of axes 2 and 6 in August had a magnitude of 0.00063, then in November 1969 it reached 0.00138.


©1976 Plenum Publishing Corporation, 227 West 17th Street, New York, N.Y. 10011. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission of the publisher. A copy of this article is available from the publisher for $15.00.

289
Fig. 1. Graph of the occurrence of maximum settlements (markers Nos. 16 and 17) in time.

Fig. 2. Diagram of the settlements of the foundations under the longitudinal bearing wall of the extreme row of the building at different periods of time. 1) June; 2) September; 3) December (the numbers of the observation markers are indicated in the circles).

An examination of the structures at the start of stabilization of settlements showed that through cracks had occurred in many blocks of the bearing walls. The structural elements of the stair wells had misalignments visible to the eye. The floor slabs between stories were also out of alignment and shearing of the concrete blocks occurred in some support places on the longitudinal walls.

A special investigation was made to determine the causes of the damaged state of the building, as a result of which it was established:

1. During the construction period the winter was extremely severe — a low negative temperature was observed for six months, the sum of the mean monthly negative temperatures being 27°C greater than the average value for the region of Lisakovsk [4].

2. The depth of freezing of the soils in the indicated period exceeded the standard depth by 50 cm (calculation by Eq. (6) in [5]);

3. The supporting structures in the winter were constructed without special protection of the base against freezing.

4. The hydrogeologic conditions of the construction site permit relegating the base soils to conditionally nonheaving soils [1, 6].

5. In the spring thawing occurred rapidly within 0.6–0.8 month.

Thus, the structure was constructed on a frozen-through base. The presence of a basement and absence of special protection promoted freezing of the base under the foundations to a depth of 2 m, which permits relegating the base soils to heaving soils.

Thawing of the soil in the spring led to a marked decrease of its bearing capacity and was accompanied by slumping phenomena, increase of the pore-water pressure, and the formation of considerable regions of a limiting stressed state under the foundations.

The nonuniform deformations of the thawing bases governed the characteristics of the behavior of the superstructure. Depending on the rate of settlements, the load was redistributed on the base, creep properties of the material of the structures were displayed, and stress concentration occurred, which was not taken into account in calculating the structure. The deformations of the building exceeded the allowable values considerably [5–7]. Thus, the magnitude of the average settlements exceeded the allowable by more than 2 cm, and the difference and rate of settlements by more than twofold.

Nonobservance of the requirements of the Construction Specifications and Regulations (SNIP) concerning protection of the base against freezing when constructing structures during the winter in the presence of a high groundwater level in the form of a perched water table was the main cause of the impermissible deformations of the building.

To correct the deformations of the building, the cracked blocks were strengthened by bands of rolled angles, the cracks were caulked with mortar, the slopes of the floor slabs were leveled by means of inserts.