EARTH PRESSURE ON LOCK CHAMBER WALLS DURING CONSTRUCTION*

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In recent years publications have appeared which pointed out the considerable excess of the measured earth pressure on lock walls in comparison with the calculated pressure [1, 2]. Thus, on the locks of the Lenin and 22nd Party Congress Volga hydroelectric stations the measured earth pressure on the walls was about triple the calculated determined by the standards during observations in the construction and operating periods. This fact makes doubtful the validity of the existing standards for designing locks. The need arose for a detailed study of the character of change of earth pressure in order to determine when and why the earth pressure increases.

Two periods, construction and operating, are usually distinguished when investigating the character of formation of stresses in the soil-structure system. In the first period stresses form when various structural bonds develop in the soil, and in the second period the stresses change under the effect of cyclically varying hydrostatic pressure and temperature effects. Creep and plastic deformation of the material of the structure and backfill and foundation soils are also of importance. The boundary between these periods is usually considered to be the time of completion of the main construction operations; however, full-scale observations show that the formation of earth pressure continues during the first lockings roughly until the backfill is completely flooded. Therefore, it is more correct to refer the end of the period of formation of earth pressure to the time of establishment of a constant operating regime of the groundwaters.

*Based on experience in the construction and operation of the locks of the Lenin, 22nd Party Congress, and Votkin hydroelectric stations.

Fig. 1. Formation of lateral earth pressure on lock chamber walls of the Lenin Volga station during construction. a) First stage (from March through June, 1955); b) second stage (from July through October, 1955); c) third stage (from November, 1966 through May 1966). 1) Soil dynamometers; 2) drain. GWL: Groundwater level.
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Fig. 2. Diagrams of the measured lateral earth pressure on the lock chamber wall of the 22nd Party Congress Volga hydroelectric station.
a) Position of backfill from December 15, 1958 through June 30, 1959; b) position of backfill on October 30, 1959. GWL: Groundwater level.

Usually little attention is paid to an evaluation of the conditions of formation of stresses during the construction period, although the author's analysis of full-scale data established that the magnitude of earth pressure on the wall depends on the conditions under which the soil was placed in the spaces being backfilled. This, of course, does not mean that the changes of earth pressure in the operating period can be neglected, but in most cases we must seek the cause of the considerable excess of the value of earth pressure on the lock wall over its calculated value, primarily under the construction conditions. Temperature deformations of the lock during construction in the case of a sufficiently high rate of backfilling play a less significant role, and in most cases they can be disregarded.

The conditions of formation of earth pressure during the construction period can be traced for several locks. The sample of the Lenin Volga hydroelectric station is the most characteristic. During 12 years of full-scale observations on this lock it was found that the measured earth pressure on the chamber walls exceeds the calculated by a factor of 2.8. In this case the increase of pressure during the operating period (10.6 years of observations) was only 10-15% of the total value of the measured pressure. The main increase of pressure occurred during construction. To reveal the causes of this phenomenon we will examine in greater detail the sequence of operations in the construction of the lock and the character of the pressure increase. Observations of earth pressure during the construction period lasted 1.5 years, from the start of construction of the embankment until the start of permanent operation.

During construction the external load on the lock chamber walls from the backfill changed three times: the first load occurred during backfilling of the spaces to a height of about 13 m, a further increase occurred on placing