Censuring the durability of foundations of buildings and structures

Nodira Kholova and Ravshan Abdullaev
Bukhara Engineering Technological Institute, Bukhara, Uzbekistan

E-mail: xolovanodiraaxmedovna66@gmail.com

Abstract. The article covers the results of field full-scale experimental research aimed at revealing the effect of horizontal waterproofing structures of walls on the capillary rise of moisture. Conclusions and recommendations for waterproofing walls using local materials have been given. Based on comparative comparisons of the results of experiments, the article covers that the rise of moisture along the wall is significantly less in the case of laying marble or concrete tiles on waterproofing sand-cement mixtures.

1. Introduction
In recent years, results of research aimed at studying the technical condition of buildings and structures and archival data collected during their operation show that the technical condition of most previously built buildings and architectural monuments has deteriorated, some parts of which have uneven subsidence. As a result, cracks in the walls of buildings and structures, significant deviations of high towers from the vertical, as well as uneven subsidence also have been observed. One of the main reasons of these cases is anthropogenic factors in the environment, including rising groundwater levels, failure to ensure proper drainage of snow and rainwater through special ditches, increased soil moisture, which leads to an increase in the overall deformation of the basement of buildings, rise of capillary moisture along the wall and erodes at the top of the walls under the influence of temperature differences [1].

In order to ensure the long life of buildings and structures in operation, it is first necessary to study their ground and foundations, assess their technical condition and, if necessary, strengthen them. The main purpose of assessing the technical condition of buildings and structures is to establish an optimal regime for their operation. The problem of rational technical operation of buildings and structures is mainly aimed at keeping them in a satisfactory technical condition with low operating costs. Currently, there is no database on the technical condition of most of the buildings and structures in operation. In particular, without knowing the depth of the foundation of buildings and structures, the size of the heel, the physical and mechanical properties of the ground, it is impossible to assess the level of strength and reliability of the ground and foundations, as well as the reliability of the whole building-foundation-ground system [2].

Problem of moisture protection of walls, which is one of the factors negatively affecting the deterioration of technical condition of buildings and structures, remains an urgent problem today.

Hence, in aggressive conditions, it is necessary to protect the walls of building from capillary water that absorbed through the foundation. Nevertheless, in recent years, there are many cases of deterioration of their technical condition because of increased soil moisture in the ground of buildings and structures, as well as deterioration of the waterproofing layer between the foundation and the wall. The main
reasons for this are, on the one hand, rising groundwater levels, improper organization of the drainage of snow and rainwater, and in some cases due to failures in engineering communications, water leakage from them, increased soil moisture, which leads to an increase in general deformation, and on the other hand, in some cases, because of violation of the waterproofing of the foundation, the rise of moisture in the wall and the erosion of cement-sand or gypsum mixtures between the wall bricks under the influence of hot and cold, partial compression deformation occurs. Compression, crushing deformation in the brick wall, and deformation of the ground soil are combined, and at certain values of the total deformation, vertical cracks appear along the wall at the top, unable to withstand the stresses in some parts of the walls, and subsidence of the foundation in those sections. These indicate that the state of finite equilibrium of soil soils is disturbed [3,4].

At present, there is no theoretical solution that can determine the vertical movement of water in soils or various objects. The main reason for this is not only that the influencing factors are ultimately numerous, but also that they are variable, i.e., have random quantities [5,6]. For example, a comparative analysis of available sources shows that water rise depends on many factors such as soil type, density, natural moisture, porosity, solid particle size, chemical composition, ambient temperature (soil, water, air) and its change, rising water pressure, the depth of groundwater, etc. Quantitative indicators of mentioned factors cannot be determined for each variable situation. This means that the problem cannot be solved theoretically, and it can only be based on “experimental” method. Therefore, we carried out some research with a group of engineers on this problem.

2. Methods and results
In order to study the effect of waterproofing construction on the capillary rise of moisture in frame of research, scientists and engineers at a special experimental site carried out scientific experiments on problem of moisture protection of the walls of buildings and structures.

![Figure 1. Raw brick wall: a) 1 cm thick sand-cement mixture and concrete foundation, b) 2 cm thick sand-cement mixture, black paper layer coated bitumen layer, concrete foundation, c) 1 cm thick marble tiles, 1 cm thick sand-cement mixture and concrete foundation, d) 3 cm thick sand-cement mixture and concrete foundation.](image-url)
In these experimental tests, waterproofing layers of capillary waterproofing of various constructions were constructed and moisture changes were observed over time in the upper parts of the foundation of the wall. In all experiments, water was retained from the level of the foundation heel to the same height.

Results of experiments show that when a raw brick wall was laid over a sand-cement mixture with a thickness of 1 cm (figure 1, a), the moisture content was initially higher than that of a sand-cement mixture with a waterproofing layer of 3 cm (figure 1) and then, after a period of 4-5 months, a relative increase in moisture was observed when the sand-cement mixture was 3 cm thick, and it continued to grow. In our opinion, if the sand-cement mixture is 3cm, microcracks may appear in the waterproofing layer due to the shrinkage deformation that occurs in the mixture over time, leading to an increase in moisture.

![Figure 2. Raw brick wall: a) 3 cm thick marble tiles, 1 cm thick sand-cement mixture and concrete foundation, b) single-layer mastic layer and concrete foundation c) double-layer mastic layer, concrete foundation d) concrete foundation.](image)

In the experiments in the scheme (figure 2, g) in which the brick wall was laid without the construction of a waterproofing layer, the increase in humidity was 40-50% higher than in the experiment in the scheme (figure 1, b) with a waterproofing layer, and later in both scheme experiments, a gradual increase in humidity over time was observed. Moisture increases over time when 1 cm thick marble tiles are laid on the sand-cement mixture and waterproofing is installed (figure 1, c) and in the same structural waterproofing scheme (figure 2, a) but the marble tile is 3 cm thick. In both experimental schemes, the change in humidity over a period of up to 3 months was almost the same, and in subsequent experiments on figure 2 (a), the humidity increased by 25–30%, probably due to the low thickness of the marble tile. In figures 2 (b) and (c), the change in humidity over time (observation period 3 months) was almost non-existent when the waterproofing was made from a dry mixture of imported Penetron brand, prepared by absorbing a water-soluble liquid. However, due to the high cost of foreign-made waterproofing materials Penetron is more difficult to recommend in practice.
Figure 3. Baked brick wall: 3.5 cm thick sand concrete slabs, 1 cm thick sand-cement mixture and concrete foundation.

In experiment 3 (a), the waterproofing layer construction consisted of fine-grained 3.5 cm thick concrete slabs compacted on a 10 mm thick sand-cement mixture and when a solid brick wall was laid over it, a decrease in moisture over time was observed despite the winter season. This means that, as noted above, fine-grained dense concrete is less permeable to moisture.

3. Conclusions

From the experiments in all schemes, it can be concluded, in the first 1-2 years after the walls of the building are laid, there are no significant changes in humidity in terms of absolute amount. Based on comparative comparisons of the experimental results, it can be seen that the rise of moisture along the wall is significantly less in the case of laying marble or concrete tiles on the waterproofing sand-cement mixtures.

According to the results of the research, the following main conclusions and recommendations can be made on the waterproofing layers to be built to protect the wall from moisture in the basement part of the foundation:

- In waterproofing constructions made of sand-cement mixture in the ratio 1:2 recommended for seismic areas on the recommendation of normative documents (figure. 1, a and g), the thickness of sand-cement mixture does not exceed 20-30 mm. However, according to the normative documents if the waterproofing to be built is performed with metal or plastic mesh from 10x10 mm to 20x20 mm, no shrinkage deformation cracks will occur and no increase in moisture will be observed.

- Based on the experience of operation of buildings and structures, it is not advisable to recommend horizontal waterproofing of such a composition on the foundation in buildings and structures with a high level of responsibility, given the short-term deterioration of fibrous and bituminous layers.

- In the case of fine-grained concrete and marble tiles up to 3.5 cm thick in the sand-cement mixture on the concrete foundation, the rise in moisture was very small and had a tendency to decrease over time (figure. 1 c, figure. 3 a), and such practical application of waterproofing structures in larger scales would be more expedient.

- Results of experiments on waterproofing schemes of different constructions suggest that the laws of change of capillary moisture passing through the plinth in the walls have an increasing character over time, and therefore they need to be studied over a long period.

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