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STUDY OF THE INFLUENCE OF SOIL SALINITY ON THE FOUNDATIONS OF APARTMENT BUILDINGS IN COMPLEX CLIMATIC CONDITIONS (USING THE EXAMPLE OF THE CITY OF URGENCH)

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Abstract

In this article, the factors influencing the foundation structures of multi-apartment residential buildings in operation in an area with complex climatic and hydrogeological conditions are scientifically investigated and analyzed. The object of the research is the territory of the city of Urgench, long-term meteorological observations of the territory, the level of groundwater and engineering-geological properties of soils were studied. In the research process, based on laboratory analysis of soil samples, the types and degrees of soil salinity were studied. The obtained results were compared and evaluated with regulatory documents in the field.

Keywords

multi-apartment residential buildings; foundation structures; difficult climatic conditions; soil salinity; aggressive environment; groundwater; sulfate and chloride ions; concrete and reinforced concrete wear; technical condition assessment.

INTRODUCTION

Today, the acceleration of urbanization processes in the world, the growth of the population, and the expansion of the housing stock make it a scientific and practical problem to constantly monitor and check the technical condition of multi-apartment residential buildings to ensure operational reliability. For cities with complex climatic and hydrogeological conditions, ensuring the longevity of building operation is of great importance. In complex climatic conditions (uneven distribution of precipitation, sharp changes in air temperature, and high groundwater levels), soil salinization (aggressive environment) leads to changes in the physical, mechanical, and chemical properties of soils, activating the processes of destruction of concrete and reinforced concrete structures. In this regard, the analysis of climatic and geological processes affecting the foundation structures of apartment buildings helps to assess the technical condition of the structures. The main goal of this study is to determine the negative impact of soil salinization on the foundation structures of multi-apartment residential buildings in an area with complex climatic conditions.

METHODOLOGY

This study is aimed at studying the influence of soil salinity and aggressive environments on the foundation structures of multi-apartment residential buildings in complex climatic and hydrogeological conditions; in this process, long-term meteorological data of the territory were analyzed, and the maximum and minimum values of air temperature, temperature amplitude, and seasonal precipitation were determined.

The technical condition of apartment buildings is formed under the combined influence of natural-climatic, subjective, operational, and other factors in the processes of their design, construction, and operation. Failure to take these factors into account can lead to deformations in structures, acceleration of physical wear, and a decrease in the level of operational safety. Therefore, in the process of assessing the technical condition of buildings, it is necessary to rely on the requirements of current urban planning norms and rules, as well as building regulations.

[1–5].

RESULTS

The city of Urgench, located in the northwestern part of the Khorezm region[2], is designated as part of the I-th construction and climatic zone, the city is located in the territory of alluvial deposits of the Amu Darya delta, and the results of engineering and geological studies show that the soil consists mainly of sandy and loamy soils, the depth of these layers can reach up to 20 m. Based on the analysis of long-term meteorological observations (1961-2022) in the region, we can say that the climate of the region is complex, in the summer months the air temperature rises to +43...+45 °C, and in the winter season it drops to −30...−33 °C, as a result of which the amplitude between the maximum and minimum temperatures is 78 °C, the prolonged summer heat period intensifies the processes of thermal expansion and contraction in building structures, causing the appearance of cracks and deformations [2].

The most favorable temperature for the human body is recorded in the range of 18-24 °C, mainly in May and September [8].

The amount of precipitation in the region averages about 140-150 mm per year, the main part of which falls in the winter and spring seasons (Fig. 1).

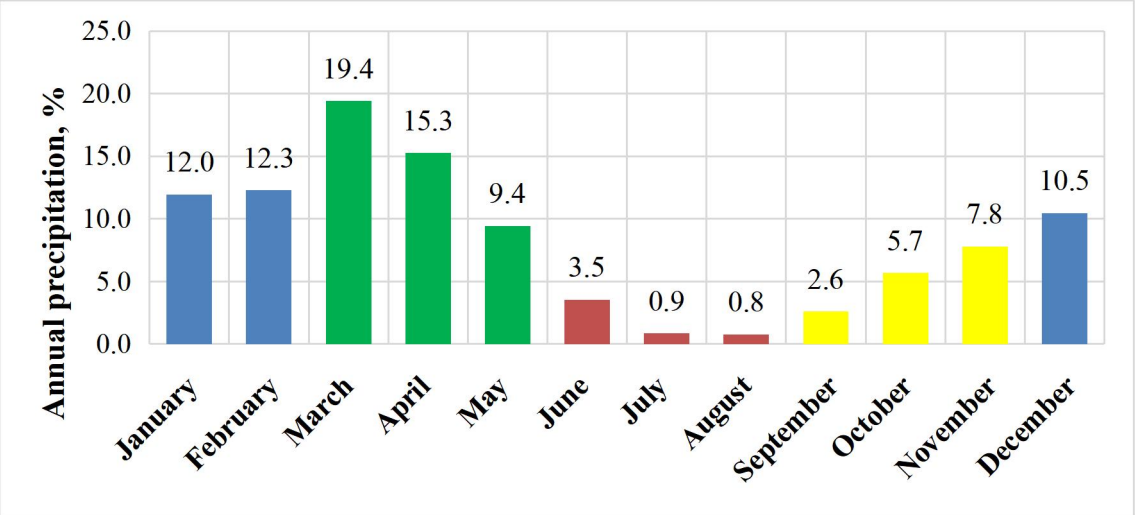

Figure 1. Monthly precipitation in the city of Urgench, %

Precipitation averages 34.6% in winter, 44.1% in spring, 5.2% in summer, and 16.1% in autumn. Uneven distribution of precipitation causes moisture in the foundation and wall structures of the building, resulting in accelerated physical aging of concrete and reinforced concrete elements [8]. The impact of precipitation on building structures: moisture can be in the form of water or ice, and the natural moisture content of the structure can be in the form of drip-liquid or condensation. Drip-liquid wetting occurs due to the seepage of rainwater and melted snow into the damaged structure (cracks and cracks). Despite its relative purity, rainwater, passing through polluted air, absorbs harmful substances, as a result of which the composition of the falling rainwater changes and becomes aggressive for the building structure, which leads to a violation of the technical condition of the structure.

In porous structures and large-sized single-layer structures with poorly closed joints, rain moisture penetrates deep into the walls, and this moisture can even penetrate into the room.

The moisture zone in the wall, formed by spraying water onto the pedestrian walkway surrounding the building, can reach up to 50 cm, therefore the base part of the building, which does not have a dense surface, is damaged much faster.

Figure 2. Soaking of the foundation of an apartment building after rainfall.

In such complex conditions, special structural and waterproofing measures must be taken for the foundations of buildings, otherwise the probability of uneven settlement of the foundation, building deflection, and the appearance of cracks and fissures in the wall structures increases.

Groundwater in the region is formed mainly from the waters of canals passing through the city, irrigation of suburban and urban areas, therefore the period of maximum rise of groundwater occurs in the spring months, and the depth is mainly 1.0-3.0 m.

Due to the high groundwater level, the activation of physical deterioration processes of the foundation structures of apartment buildings can be observed [5].

DISCUSSION

Under the influence of surface and groundwater, various chemical changes occur in the soil composition, as a result of which the soil composition becomes saline. The classification of saline soils by type [10] is divided into separate groups (Table 1).

Table 1
Classification of soil composition by types of salinity.

№	Naming of salinity types	Cl^-/ SO_4^{2-} 100g in dry soil, mg
1	**Chloride**	> 2
2	**Sulfate-chloride**	2-1
3	**Chloride-sulfate**	1-0,2
4	**Sulfate**	< 0,2
5	**Sodic soils**	the ratio of CO_3^{2-} and HCO_3^- ions to the sum of Cl^- and SO_4^{2-} ions should be greater than 1:3

These chemical substances in the soil negatively affect the structures of apartment buildings, leading to the process of structural destruction, ions in the soil affect building structures as follows:

➢ **SO_4^{2-}** – sulfate ions (most harmful) severely damage reinforced concrete structures in foundations and humid environments, react with concrete, causing an increase in concrete volume, accelerating the process of destruction in the structure, and ultimately leading to the loss

of concrete strength.

➢ **Cl^-** – chloride ions (the most dangerous for reinforcement in reinforced concrete structures) disrupt the protective environment of concrete, resulting in daily corrosion of the reinforcement and its expansion, causing concrete cracking.

➢ **CO_3^{2-}** – carbonate ions (which cause slow but constant damage) react in the concrete composition, leading to the carbonation process, which occurs slowly but becomes dangerous in the long term.

➢ **HCO_3^-** – bicarbonate ions (indirect action) participate in the alkalinity of water and the initial stage of the carbonation process, independently not strongly destructive, but react with other ions (SO_4^{2-}, Cl^-) to enhance their effect.

➢ **Ca^{2+}, Mg^{2+}, (Na^+ + K^+)** ions in the soil have a secondary effect on the structure, weakening its structure by disrupting the integrity of concrete as a result of their interaction with other ions. The chemical composition of the samples taken from the soil of the studied area is presented in Table 2.

Table 2

Chemical state of soils under the influence of groundwater

№	Number	Depth, meters	Dry residue, mg/kg	Ionic quantity, mg/kg						pH
				HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^++K^+	
1	C-1	0,0-2,7	5090	270	430	2590	230	90	1140	9,0
2	C-2	0,0-2,6	1930	340	430	480	260	90	290	9,0

Comparison of the results obtained from the sample with Table 1 shows that the chemical state of the soils is sulfate and chloride-sulfate types of salinity.

Table 3

Types of soil by degree of salinity

№	Cl^- / SO_4^{2-}	Naming of salinity types	pH
C-1	**0,16**	Sulfate	9,0
C-2	**0,89**	chloride-sulfate	9,0

For the soil composition to be classified as soda based on salinity types, the water must contain CO_3^{2-} (carbonate ions), which are present in waters with a pH > 8.3, according to Table 2, the carbonate ions are equal to pH=9.0, which indicates that the water in this region has a strongly alkaline environment, and in neutral or slightly alkaline waters, HCO_3^- (hydrocarbonate ions) predominates. When structures are repeatedly and for a long time moistened with a salt solution (aggressive medium), a process of destruction begins in the structures, and if this process is not prevented, the structure may fall into an emergency state (Fig. 3).
factor, arbitrary redevelopment work, inadequate organization of the embankment, and malfunctioning drainage systems lead to constant moistening of the foundations and walls, as a result of which we can add subjective factors to the list of factors influencing the process of physical deterioration of apartment buildings [3].

Figure 3. Influence of the aggressive environment on the structures of multi-story residential buildings.

CONCLUSION

The influence of operational and climatic factors negatively affecting the structures of multi-apartment residential buildings was analyzed, based on which, as a result of the chemical influence of precipitation and groundwater on the soil, which are considered climatic factors, the degrees of soil salinity were compared with the tables presented in the literature, and the soil was divided into separate groups according to salinity indicators and grouped according to the degree of aggressiveness on foundation structures.

Strengthening preventive measures to protect the foundation structures of residential buildings from salinization contributes to the stable maintenance of the technical condition of apartment buildings located in difficult climatic conditions.

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