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DURABILITY OF REINFORCED CONCRETE PILES IN AGGRESSIVE SOIL CONDITIONS

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Abstract

A method is given for determining the bearing capacity of driven piles in aggressive soil conditions. The shear resistance f0 of concrete corrosion products and the resistance of piles Φk in the area of possible corrosion damage to concrete were determined. Taking into account the influencing factor of the corrosion process on the bearing capacity of piles in medium, highly aggressive environments, primary and secondary protection of piles have been proposed.

Keywords: saline soils, soil resistance along the lateral surface of the pile, concrete corrosion, predicted corrosion depth, impregnating compositions, sulfate-resistant portland cement.

Introduction

Soils and groundwater in many regions of Uzbekistan are characterized by the content of water-soluble salts that have an aggressive effect on the foundation material. For the construction of above-ground structures in conditions of salinization of the surface layer of soil, an important task is to impart resistance and protection from corrosion to the foundation structures of buildings and structures [1, 2, 3, 5]. Recently, pile foundations have been used for agricultural buildings in aggressive soil conditions [7]. The effectiveness of various methods for increasing the durability and anti-corrosion protection of reinforced concrete elements in saline soils is largely determined by the reliability of assessing the type and degree of aggressiveness of the environment and the forecast of changes in aggressiveness during operation.

It has been established that corrosion of the surface of the pile material affects their load-bearing capacity [8,9,10,11]. In this case, the influence of the factor depends on the degree of stress-strain state of the space around the pile, the material of the piles, the aggressiveness and temperature of the medium, as well as the rate of filtration of ground or surface water. The work indicates [5] that in the process of interaction between an aggressive environment and cement stone, calcium oxide is neutralized, which makes up 60...70% in cement stone, as well as oxides (silica, alumina and iron oxide), which provide a significant effect on the shear resistance of corrosion products. Based on this, it should be expected that the required values of shear resistance to concrete corrosion are conveniently determined in laboratory conditions by testing corrosion products on a single-plane shear device GGP-30, taking into account the methodology [4].

The studies were carried out in an aggressive environment characteristic of soils and groundwater in Central Fergana. The composition and content of aggressive ions in the solution are as follows: SO^{11}_4= 3520mg/l; cl^1=105 mg/l; HCO^1_3=10 mg/l; Ca^{11}=230 mg/l; Mg^{11}=30 mg/l; Na^1 +K^1= 3485 mg/l.

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Below are the results of experiments testing corrosion products of the foundation material.

№ Exp.	Shear strength $\tau(f_0)$ at σ MPa			
	0	0,1	0,2	0,3
1	0,064	0,13	0,17	0,17
2	0,060	0,102	0,200	0,200
3	0,073	0,120	0,143	0,250
4	0,080	0,102	0,175	0,220

Based on the obtained data, the shear resistance f_0 of concrete corrosion products within the normal pressure range σ = 0÷0.3 MPa can be presented in the following form:

$$f_0 = 0.05\sigma + 7 \quad (1)$$

From expression (1) it can be noted that with increasing compressive stresses, the influence of concrete corrosion products on the load-bearing capacity of the pile decreases. If we take into account that the most active corrosion processes occur in the aeration zone (zones of alternate wetting and drying), then the influence of the above factor occurs within certain limits along the length of the piles. Obviously, the predicted area of active corrosion along the length of the piles should be assigned according to the lithological structure of the soil, groundwater level (including the predicted one) and the aggressiveness of the environment. Based on this, determine the resistance along the lateral surface of the piles f0 in the area of active concrete corrosion in accordance with the lateral soil pressure at the contact of the piles with the soil at the considered depth. The resistance of piles in the area of possible corrosion damage to concrete Fk, taking into account (1), can be written as:

$$\Phi_к = m_к u_k (0.05\sigma + 7)l_k \quad (2)$$

m_k – reliability coefficient equal to 1.2;

u_k – pile perimeter taking into account predicted concrete corrosion, m;

σ - is the normal pressure acting along the lateral surface of the pile shaft at the considered depth of the layer;

l_k - is the thickness of the soil layer in which active corrosion of concrete is expected, m.

Taking into account the influence of the corrosion process on the load-bearing capacity of piles in medium, highly aggressive environments, methods for their protection are used. The primary protection of concrete and reinforced concrete in aggressive soil environments is to increase the ability of concrete, reinforcement and reinforced concrete to resist the effects of a corrosive environment by changing the composition and structure of concrete before or during the manufacturing process [1,7]. This is achieved by choosing stable raw materials, concrete compositions, additives, types of reinforcement and concrete, methods of manufacturing and calculating structural elements.

Secondary protection consists of increasing the corrosion resistance of concrete after its production by partially or completely filling the pore structure with various chemically resistant materials (surface or full impregnation), installing surface protective coatings, or by artificially lowering the level of aggressive groundwater.

Currently, for anti-corrosion protection of reinforced concrete piles, foundations and other underground structures in natural highly aggressive soil environments, impregnating compositions based on styrene-indene resin, pyroplast and polyisocyanate K*, urea-formaldehyde resin, penetrating Hydrocem, bitumen, etc. are widely used[3] . Depending on the type of aggressiveness of groundwater, Portland cement is usually used as a binder for concrete intended for subsequent impregnation. In areas with saline soils and highly mineralized groundwater, sulfate-resistant Portland cements should be used to make concrete.

Reinforced concrete piles exposed to dynamic shock loads during the driving process must be made from dense concrete with a water resistance grade of at least B-6, since a decrease in the initial density of concrete leads to a sharp decrease in the number of impacts before failure and an increase in micro-damages in the concrete of the piles after driving.

When carrying out impregnation in areas with a hot climate, it is necessary to take measures to protect the impregnation baths from direct heating by sunlight, since under these conditions the possibility of solvent evaporation increases and, as a result, the viscosity of the impregnating composition increases. Before impregnation, the surface of reinforced concrete products is pre-cleaned and dust-free with compressed air.

Before impregnation of products in baths, a laboratory check of the impregnation mode is carried out on cube samples with an edge of 10 cm. If after impregnation for 8 hours when splitting the control samples, the depth of the impregnated layer is at least 10 mm, then the products are impregnated.

The effect of impregnation on the resistance along the lateral surface of piles is established based on the results of pile tests [1]. It is known that when testing reinforced concrete piles with various anti-corrosion coatings after driving, the protective properties of the anti-corrosion coatings decrease. In turn, protective coatings will have a different effect on the process of immersion of piles into the ground, and for “hanging” piles on the value of the load-bearing capacity of the structure as a result of changes in soil friction along the side surface of the pile. It is known that hanging piles protected with bitumen mastics in clay soils reduce the load-bearing capacity compared to piles without protection by more than 30%, and when the piles are coated with urea-formaldehyde resin by up to 20% [3].

Based on the data obtained, parameters taking into account the influence of impregnation of sandy and clayey saline soils are proposed to be taken within the range of 0.8-0.9. Here the lower limit of the parameter corresponds to saline sands.

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