Journal of Positive School Psychology
2022, Vol. 6, No. 6, 5889-5892 http://journalppw.com

Mathematical model of mass transfer of reinforced concrete structures of hydraulic structures with corrosion protection in aggressive environment

[1]Prof. Makhmudov Ilhomjon Ernazarovich, PhD
[2]Sadiev Umidjon Abdusamadovich, PhD
[3]Andrey Petrov

[123]Research Institute of Irrigation and Water Problems of the Ministry of Water Resources of the Republic of Uzbekistan

Abstract: Mathematical model of change in parameters of water absorption of waterproofing material in case of natural convection for arbitrary moment of time is developed. The dependence for determining the time of reliable serviceability of reinforced concrete elements of HS with anticorrosive and sealing protection in the conditions of aggressive environment has been obtained.
Key words*:* degradation of materials, modeling of mass transfer process, determination of reliable operation time.

Degradation of materials and structures in aggressive media occurs as a result of chemical interaction of their components with components of protective material. Depending on the ratio of rates of diffusion and chemical action, degradation occurs in one of three areas: external diffusion-kinetic, when the rate of diffusion of the medium is less than the rate of destruction, the destruction of the material occurs in the surface layer - heterogeneous degradation; internal kinetic, when the rate of diffusion of the medium is more rapid chemical reactions and the entire volume of material is destroyed - homogeneous degradation; internal diffusion-kinetic, when the rate of chemical reaction is commensurate with the rate of

This paper considers the process of mass transfer of reinforced concrete structures of hydraulic structures with protective composite

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} - a\frac{\partial C}{\partial x} \qquad (1)$$

where: $$D = \frac{4R^2}{\pi^2 \Delta t}\ln\left(\frac{Q(t_2) - Q(t_1)}{Q(t_3) - Q(t_1)}\right)$$

similarity criterion is used. Nusselt similarity criterion

ratio between convective mass transfer from

material under conditions of aggressive environment. Due to the preaccepted symmetry of the initial

distribution and the conditions of changing the concentration of the material, the concentration distribution at different moments of time will remain symmetrical. Hence, the process of changing the concentration is completed by establishing the concentration at the level of the environment.

We model the mass transfer process of reinforced concrete HS structures with corrosion protection under corrosive conditions. It is assumed that the concentration depends on only one coordinate *x* and we assume that the concentration field is one-dimensional. In this case, we can use the differential mass transfer equation for one-dimensional formulation [1].

During modeling it is assumed that during mass transfer between the surface of protective layer of concrete and water flow in case of natural convection - Nusselt

$Nu \square \frac{al}{D}$ - characterizesthe —

liquid (from water) to the surface of composite material applied to the surface of reinforced concrete of HS structure.

Where: a- mass transfer coefficient, $\frac{m}{s}$; l -characteristic linear dimension, m; D- diffusion coefficient, $\frac{м^2}{c}$.

Then equation (1) will take the following form:

$$\frac{\partial C}{\partial \tau}=\frac{1}{Nu}\frac{\partial^2 C}{\partial \hat{x}^2}-\frac{\partial C}{\partial \hat{x}} \qquad (2)$$

Thus, the equation of mass transfer from water to the surface of the protective layer of reinforced concrete GTS is obtained. To solve equation (2) we introduce function $F(x)$.

$$C(\hat{x},\tau)=e^{-\lambda\tau}\Phi(\hat{x}) \qquad (3)$$

$$\frac{1}{Nu}\frac{\partial^2 \Phi}{\partial \hat{x}^2}-\frac{\partial \Phi}{\partial \hat{x}}+y\Phi=0 \qquad (4)$$

Letuswritethedesiredfunctionas $\Phi=e^{\beta\hat{x}}$ ..Thenfrom(4)weobtainthe characteristic equation, and after appropriate mathematical operations we obtain

$$\Phi(\hat{x})=A_1\exp\left(\frac{1+\sqrt{D_1}}{2\hat{\varepsilon}_S}Nu\cdot\hat{x}\right)+A_2\exp\left(\frac{1-\sqrt{D_1}}{2\hat{\varepsilon}_S}Nu\cdot\hat{x}\right)$$

We introduce dimensionless parameters $x=l\hat{x}$, $t=\frac{l}{a}\tau$.

(5)

where: $D_1=\frac{Nu-4y}{Nu}$.

Given the initial and boundary conditions we obtain the following equation for the coefficients:

$$\begin{cases} A_1+A_2=1, \\ A_1\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)+A_2\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)=e^{\lambda\hat{\varphi}} \end{cases} \qquad (6)$$

where: $\hat{\varphi}$ -reinforced concrete strength coefficient of GTS, λ - degradation parameter.

By solving the system of linear algebraic equations by Cramer method we determine the unknown coefficients of equality (6) A_1 *and* A_2 , where we have

$$\Delta=\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)-\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)$$

$$,\quad \Delta_1=\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)-\exp(\lambda\cdot\hat{\varphi})$$

$$\Delta_2=\exp(\lambda\cdot\hat{\varphi})-\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right).$$

$$\begin{cases} A_1=\frac{1}{\Delta}\left[\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)-\exp(\lambda\cdot\hat{\varphi})\right]; \\ A_2=\frac{1}{\Delta}\left[\exp(\lambda\cdot\hat{\varphi})-\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)\right]. \end{cases} \qquad (7)$$

$$\Phi(\hat{x})=\frac{1}{\Delta}\left\{\begin{aligned}&\left[\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)-\exp(\lambda\cdot\hat{\varphi})\right]\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{x}\right)+\\&\left[\exp(\lambda\cdot\hat{\varphi})-\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)\right]\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{x}\right).\end{aligned}\right. \qquad (8)$$

$$C(\hat{x},\tau)=\frac{\exp(-\lambda\tau)}{\Delta}\left\{\begin{aligned}&\left[\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)-\exp(\lambda\cdot\hat{\varphi})\right]\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{x}\right)+\\&\left[\exp(\lambda\cdot\hat{\varphi})-\exp\left(\frac{1+\sqrt{D_1}}{2}Nu\cdot\hat{\varphi}\right)\right]\exp\left(\frac{1-\sqrt{D_1}}{2}Nu\cdot\hat{x}\right).\end{aligned}\right. \qquad (9)$$

The results of the numerical experiment of equation (9) are presented as a graph (Fig.1).

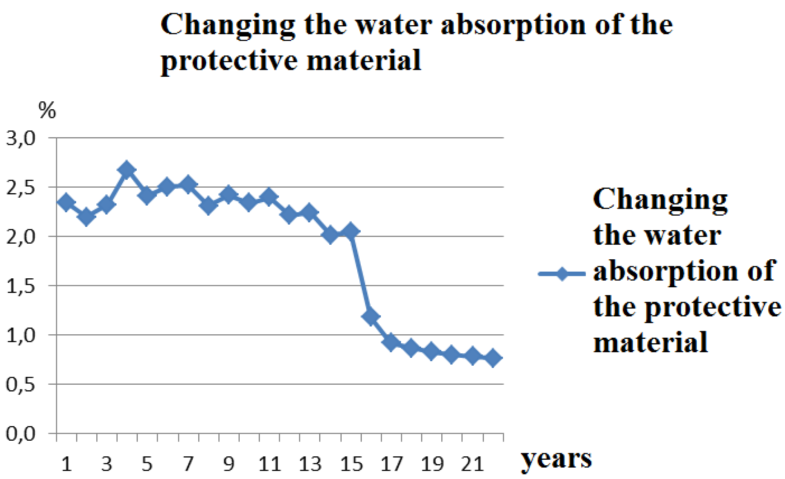
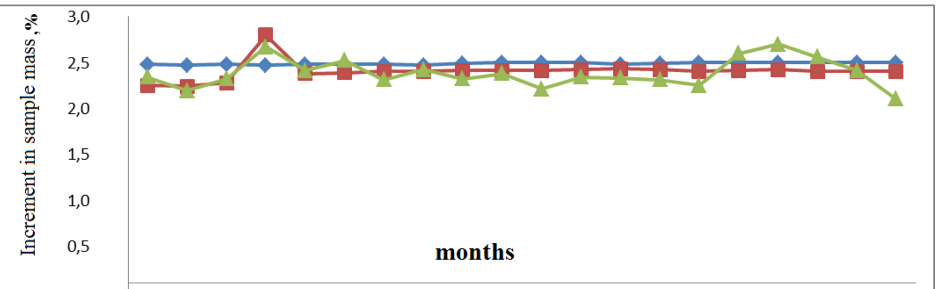


Fig.1.Graphofthefunction $C(\hat{x},\tau)$



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Analog indicators , %	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
Experimental data , %	2,3	2,2	2,3	2,8	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4
Results of numerical experiment ,%	2,3	2,2	2,3	2,7	2,4	2,5	2,3	2,4	2,3	2,4	2,2	2,3	2,3	2,3	2,3	2,6	2,7	2,6	2,4	2,1

Fig.2. Comparison of the results of normative, experimental and numerical experiments. The error does not exceed 5%.

Weobtaintheequationfordeterminingthe time, $\tau = \tau^*$ reliableserviceability of reinforced concrete elements of HS with corrosion protection in conditions of aggressive environment:

$$\tau^* = \ln\left(\frac{C^*}{\Phi(\hat{x})}\right)^{-\frac{1}{\lambda}} \tag{10}$$

REFERENCES:

1. Chernyak M Yu, Elberg M S and Sergeeva E V 2015 *Mathematical Methods of Reliability* (Krasnoyarsk: Sib. G.s. aerospace) pp40-42
2. Mirtskhulava Ts E 1981 *On the Reliability of Large Channels* (Moscow: Kolos) p 318
3. MahmudovI,SadievUAetal2013*ManagementofWaterUseinIrrigationCanals with Changing Values of the Hydraulic Parameters of the Water Flow* (Tashkent: Sat. Proceedings of NIIIVP) pp 133-136
4. Sadiev U A 2014 Hydraulic Model for Controlling Changes in the Depth of Water Flow in Irrigation Canals. Materials Int. conf. "*Innovative technologies and environmental safety in land reclamation*" (Kolomna)
5. Makhmudov I E 2015 Improving the management and use of water resources in the middle reaches of the Syrdarya river basin (Chirchik-Akhangaran-Keles irrigation district) *Republic of Ilmiy*

TechnicianAnzhuman

6. Sadiev U 2016 Management and modeling of main canals with changing values of the hydraulic parameters of the water flow *Land reclamation and water management Russia Magazine* **6**10-2
7. Sadiev U 2019 Model for predicting the durability of the viability of structures of hydraulic structures with anticorrosive and sealing protective coating *Russia magazine "Bulletin of land reclamation science"* **1**23-7
8. Sadiev U 2020 Hydraulic model of water supply regulation during fluctuations in water level in main canals *Journal of Agro Science* **1(64)**107
9. Sadiev U 2019 Calculation of hydraulic reliability parameters of Khandam channel *Journal of Agriculture of Uzbekistan* **10**36
10. Sadiev U 2018 Modeling of water resource management processes in river basins (on the example of the basin of the Kashkadarya river) *International Journal of Advanced Research in Science, Engineering and Technology*5481-7
11. Sadiev U 2016 Management and modeling in the main canals with changing values of the hydraulic parameters of the water flow *"Land Reclamation and Water Management"* **6** 10-2
12. Makhmudov Ilxomjon Ernazarovich, Sadiev Umidjon Abdusamadovich and Rustamov Shoxrux. 2021 Basic Conditions For Determining The Hydraulic Resistance To Friction In A Pipeline When A Mixture Of Water And Suspended Sediments Moves *SCOPUS va Web of Science "Zamonaviy ilm-fan muammolari va istiqbollari bo'yicha 1-xalqaro konferentsiya (ICPPMS-2021)*
13. Makhmudov Ilxomjon Ernazarovich, Sadiev Umidjon Abdusamadovich, Lapasov Khuschid Olimzhonovich, Ernazarov Azizbek and Rustamov Shoxrux 2021 Solution of the Filter Flow Problem by Analytical and Numerical Methods *SCOPUS va Web of Science "Zamonaviy ilm-fan muammolari va istiqbollari bo'yicha 1-xalqaro konferentsiya(ICPPMS-2021)*
14. Sadiev U 2021 Use of Pumps in Heat Supply Systems *International Journal of Academic Engineering Research (IJAER)* **5(4)** 49-51 ISSN:2643-9085.
15. Petrov A.A., Sadiev U.A., magazine "Hydrotechnics" No. 3, 2019, Russia, pp. 76-77.
16. Khaydar, D., Chen, X., Huang, Y. et al. Investigation of crop evapotranspiration and irrigation water requirement in the lower Amu Darya River Basin, Central Asia. J. Arid Land 13, 23–39 (2021). https://doi.org/10.1007/s40333-021-0054-9