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Mathematical modeling of the colmatation of concrete pores during corrosion

Математическое моделирование кольматации пор бетона при коррозии

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Key words: colmatation; colmatation of pores; corrosion of concrete; mathematical modeling; colmatation model

Ключевые слова: кольматация; кольматирование пор; коррозия бетона; математическое моделирование; модель кольматации

Abstract. Pore colmatation plays a positive role, since the decrease in the permeability of cement concrete due to the deposition of insoluble corrosion products in the pores leads to a slowdown in corrosion processes. The mathematical model of concrete pore colmatation based on the mass transfer equations is given, which allows to estimate the depth of corrosion damage of concretes in media of various degrees of aggressiveness. The presented model describes the rate of advance of the deposition zone of corrosion products depending on the conditions of the corrosion process. Mathematical models of the kinetics and dynamics of mass transfer accompanied by a decrease in permeability during chemical corrosion of cement stone are presented. Equations are obtained for determining the rate of advancement of the colmatation zone and the thickness of the colmatant layer during concrete corrosion. The dependence of the rate of clogging of pores and capillaries and the thickness of the sediment layer on the change in mass transfer characteristics, taking into account the porosity of the bedding layer, is shown. Graphic dependences of the rate of advancement of the colmatage zone and the thickness of the layer of corrosion products are obtained at the established porosity of the layer for cases of linear and exponential changes in the mass diffusivity coefficient over time. The obtained graphic dependences show that the intensity of the colmatation process decreases, and also illustrate a significant decrease in the intensity of the process with a slight decrease in the porosity of the sediment layer.

Аннотация. Кольматация пор играет положительную роль, поскольку снижение проницаемости цементного бетона вследствие осаждения в порах нерастворимых продуктов коррозии приводит к замедлению коррозионных процессов. Приведена математическая модель кольматации пор бетона, основанная на уравнениях массопереноса, которая позволяет оценивать глубину коррозионных повреждений бетонов в средах различной степени агрессивности. Представленная модель описывает скорость продвижения зоны осаждения продуктов коррозии в зависимости от условий протекания процесса коррозии. Приведены математические модели кинетики и динамики массопереноса, сопровождаемого снижением проницаемости, при химической коррозии цементного камня. Получены уравнения для определения скорости продвижения зоны кольматации и толщины слоя кольматанта при коррозии бетона. Показана зависимость скорости закупоривания пор и капилляров и толщины слоя осадка от изменения характеристик

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массопереноса с учетом порозности слоя кольматанта. Получены графические зависимости скорости продвижения зоны кольматации и толщины слоя продуктов коррозии при установленной порозности слоя для случаев линейного и экспоненциального изменения коэффициента массопроводности во времени. Полученные графические зависимости показывают, что интенсивность процесса кольматации уменьшается, а также иллюстрируют значительное снижение интенсивности процесса при незначительном уменьшении пористости слоя осадка.

1. Introduction

At corrosion of concrete and reinforced concrete products mudding is the process of penetration of particles (disperse and dissolved) in the pores, cracks and voids of concrete and is physical and chemical deposition in it, contributing to the grouting, reduction the water permeability of concrete, and as a result increase the frost resistance and corrosion resistance [1, 2].

Usually, the term "colmatation" is used to refer to the process of mechanical deposition of particles in the pore space [3].

Concrete is a capillary-porous material, as if permeated with a thin mesh of pores and capillaries of various sizes [4]. When the concrete is moistened, the smallest pores and capillaries are filled with an aggressive environment which interacts with calcium hydroxide to form insoluble reaction products, which clog these capillaries. Coming, as they say, "colmatation" of the pores and capillaries that leads to reduction of permeability of concrete [4].

At the interaction of components of the cement matrix of the concrete with the aggressive environment two types of colmatant are formed [5]: the first consists of a gel of silicic acid, which is formed as a result of the interaction of the silicate component of the cement stone with an aggressive environment; the second is formed as a result of the chemical reaction of the components of the aggressive environment with the main parts of the cement stone containing calcium ions: CaCO_3 , $\text{Mg}(\text{OH})_2$, etc.

With the increase in the age of concrete, the nature of its porosity changes, the volume of macropores which overgrown with cement hydration products gradually decreases, and as a result the permeability of concrete decreases [4].

In artificial conditions (at the construction and operation of engineering structures) colmatation plays a dual role – positive and negative.

The positive impact is, for example, clogging of the pores of the asphalt- and concrete when exposed to de-icing compositions [6], improvement of the strength characteristics of ceramic bricks after treatment by water-repellent and clogging compounds [7], clogging the internal structure of capillaries and pores of the wood and the formation of more strong ties of wood with cement stone in the production of arbolite [8], increasing of water-tightness of concrete structures due to colmatation of capillary pores of concrete with the introduction of special additives [9, 10], increasing the strength and density of concrete when applying waterproofing coating [11].

The negative impact of colmatation is manifested in drilling, development and operation of water wells in mechanical, chemical and biological colmatage [12]; in loss of water permeability of geotextiles and reduction of filtration properties due to colmatation of the material during water filtration [13]; in violation of the operation mode of ore-bearing wells due to deposition of solid phases formed by dissolution of metal ore-containing rocks [14].

The use of the colmatation effect for practical purposes allows to increase the degree of self-inhibition of corrosion processes and to make a choice of cement type for concrete which are operated in various aggressive environments [5].

It is necessary to make a model of collation and determine the parameters of mass transfer to have an opportunity to effectively use the process of collation in preventing the spread of corrosion front deep into the concrete.

All corrosion processes of the second type are accompanied by the release of the solid phase as a result of the chemical interaction of the concrete components and the aggressive liquid medium. The chemical interaction of the components of the aggressive environment in the liquid phase with dissolved in the pore fluid calcium hydroxide leading to the appearance of a colmatant layer flows through the reaction of the species (Figure 1):

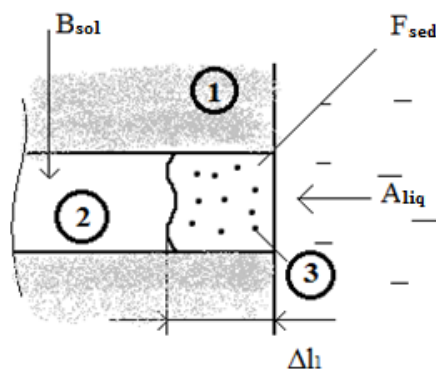
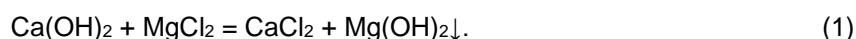


Figure 1. Pore: 1) concrete matrix; 2) pore; 3) sediment

A typical example of this type of reaction is [15]:



Calcium hydroxide (B_{sol}) interacts with an aggressive component ($A_{liq} \rightarrow \text{MgCl}_2$); because of this interaction, calcium ions Ca^{2+} (R_{liq}) pass into the liquid phase and a solid phase (F_{sed}) is formed. The process is supposed to proceed through a complex mechanism that takes place in two stages. The first stage proceeds on the external diffusion-kinetic mechanism on the interface of phases "solid-liquid" and therefore insoluble reaction product is deposited on the surface of concrete. The second stage takes place in the diffusion-kinetic mechanism [15].

The mechanism and kinetics of mass transfer at the first stage are described in detail in [15]. The second stage is discussed below.

2. Methods

To describe the nature of corrosion processes occurring during liquid corrosion of concretes, methods of mathematical modeling based on the mass transfer equations are used. Methods of mathematical physics for solving boundary problems of mass transfer are applied as a mathematical apparatus. To establish the longevity of concretes exposed to aggressive chloride-containing media, mathematical models of corrosion of concrete have been obtained, which take into account the pore colmatation. For the experimental study of the properties, structure and composition of the materials studied in the work (solid and liquid phase), methods of chemical and physicochemical analysis are used, such as: quantitative analysis of calcium cations in a liquid medium by the method of complexometric titration; electrometric method for measuring the pH of the medium; method for determining the density, water absorption and porosity of cement stone; X-ray diffraction analysis of cement stone before and after exposure to corrosive liquids.

3. Results and Discussion

To estimate the depth of corrosion damage, various equations are proposed to predict the resistance of concrete in an aggressive environment [16–20]. These equations take into account the rate of corrosion of concrete in the initial period, the rate of heterogeneous reactions and the nature of the control (kinetic or diffusion), the kinetics of the internal diffusion process with a constant diffusion coefficient in time, the porosity of the cement stone, the dependence of the mass transfer coefficients on the structure and composition of the concretes, as well as the composition and concentration of aggressive media, relative humidity (degree of saturation) and concentration of calcium ions in pore solution, formation of calcite and dissolution of hydration products, simultaneous influence of power loading and negative effects of aggressive media on concrete and reinforced concrete structures. On the basis of the theory of mass transfer processes the equations for the mathematical description of kinetic dependences of corrosion process most often occurring in practice are offered. These equations describe extensive and intensive processes of concrete corrosion inhibition [5, 21]. However, these models do not fully take into account the process of colmatation of pores and capillaries of concrete, which remains not fully understood.

We believe that at the initial moment, when only the aggressive environment interacts with the concrete at the thickness of the structure, there is a uniform distribution of the main component:

$$C_B(x, \tau) = C_{B.o.}, \quad (2)$$

where: x – coordinate, m; τ – time, s; $C(x, \tau)$ – concentration of «free $\text{Ca}(\text{OH})_2$ » in concrete at the moment of time τ at an arbitrary point with a coordinate x , in terms of CaO (kg CaO/kg of concrete); C_0 – concentration of «free $\text{Ca}(\text{OH})_2$ » in concrete in the initial time to an arbitrary point with coordinate x , in terms of CaO (kg CaO/kg of concrete).

By the time τ_1 the concentration of calcium ions at the interface will be zero. From that moment the aggressive component starts to flow inside the pores of the concrete and the reaction product, sediment, promotes the formation of a porous structure of the sediment inside the pores of the concrete.

During the time $\Delta\tau_1$ in the pore of concrete (open or through) the sediment layer determined by a formula is formed:

$$\Delta V_{m1} = (1 - \varepsilon_{sed})\pi R^2 \cdot \Delta l_1. \quad (3)$$

Here: ε_{sed} – porosity layer of sediment, which characterizes the volume of voids in the layer of sediment; R is the radius of the pore, m.

The mass of the sediment will be:

$$\Delta M_{sed1} = (1 - \varepsilon_{sed})\pi R^2 \cdot \Delta l_1 \cdot \rho_{sed}. \quad (4)$$

Dividing both parts on $\Delta\tau_1$ for which there was a mass accumulation write:

$$\frac{\Delta M_{sed1}}{\Delta\tau_1} = \frac{\Delta l_1}{\Delta\tau_1} (1 - \varepsilon_{sed})\pi R^2 \cdot \rho_m, \quad (5)$$

or in differential form:

$$\frac{dM_{sed}}{d\tau} = \frac{dl}{d\tau} (1 - \varepsilon_{sed})\pi R^2 \cdot \rho_{sed}. \quad (6)$$

Using the concept of mass flow rate, we can write:

$$\frac{dM_{sed}}{\pi R^2 \cdot d\tau} = \frac{dl}{d\tau} (1 - \varepsilon_{sed}) \cdot \rho_{sed} \rightarrow \frac{dl}{d\tau} = \frac{dM_{sed}}{\pi R^2} (1 - \varepsilon_{sed}) \cdot \rho_{sed}, \quad (7)$$

At the moment when the period of mass transfer controlled by external diffusion is completed, on the thickness of a wall of a design (product) concentration field of "free calcium hydroxide", is formed, determined by the function $C_B(x, \tau)|_{\tau=\tau_1}$ – dimension of the function: kg of the component / kg of concrete.

The mass flow density of the reagent at the interface of the phase will be determined by a known ratio similar to the first Fick's law [22]:

$$q_R(\tau)|_{\tau=\tau_1} = -k_B \frac{\partial C_B(x, \tau)}{\partial x} \Big|_{x=R_s, \tau=\tau_1} \cdot \rho_{con}. \quad (8)$$

Here: R_s – designation of the surface of the structure (the interface), through which the mass of the target component is transferred from the solid phase to the liquid; k_B – coefficient of mass conductivity of the component B_{sol} (calcium hydroxide in concrete), m²/s; ρ_{con} – density of concrete, kg/m³.

In accordance with the methodology of experimental studies of mass transfer processes, the numerical values of the mass conductivity coefficient are determined in relation to the geometric surface of the body involved in the mass transfer process. At the same time, the substance (reagent) from the liquid phase comes only through the surface of the open pores.

In the time $\Delta\tau_1$ the amount of the substance will approach from the inside of the solid phase to the surface:

$$\Delta M_{B,I} = q_R(\tau)|_{\tau=\tau_1} \cdot \pi R^2 \cdot \Delta\tau_1 = -k_B \cdot \rho_{con} \cdot \frac{\partial C_B(x, \tau)}{\partial x} \Big|_{x=R_s, \tau=\tau_1} \cdot \pi R^2 \cdot \Delta\tau_1. \quad (9)$$

This amount of substance reacts with the reagent A, the corresponding amount of the substance F_{sed} which is dropping out in a deposit as a result is formed.

During the period $\Delta\tau_1$ the single pore will be clogged with substance F_{sed} , the mass of which will be:

$$\Delta M_{FI} = V_{lim} \cdot \rho_{sed} \cdot (1 - \varepsilon_{sed}) = \pi R^2 \cdot \Delta l_1 \cdot \rho_{sed} \cdot (1 - \varepsilon_{sed}). \quad (10)$$

The total amount of substance deposited in the pores of the concrete will be determined as:

$$\Delta M_{totalI} = \Sigma \Delta M_{FI} = \pi R^2_{mid} \Delta l_1 \rho_{sed} \cdot (1 - \varepsilon_{sed}) \cdot \hat{n}. \quad (11)$$

Here: $\hat{n} = \frac{S_{surface}}{\pi R^2}$ – the number of pores per given surface.

On the other hand, this amount of substance can be defined as:

$$\Sigma \Delta M_{FI} = -k_B \cdot \rho_{con} \cdot \left. \frac{\partial C_B(x,\tau)}{\partial x} \right|_{x=R_S, \tau=\tau_I} \cdot \pi R^2 \cdot \Delta \tau_I \cdot \nu_{AD}, \quad (12)$$

where: ν_{AD} – stoichiometric coefficient.

It follows from the balance:

$$\pi R^2_{mid} \Delta l_1 \rho_{sed} \cdot (1 - \varepsilon_{sed}) \cdot \hat{n} = -k_B \cdot \rho_{con} \cdot \left. \frac{\partial C_B(x,\tau)}{\partial x} \right|_{x=R_S, \tau=\tau_I} \cdot \pi R^2 \cdot \Delta \tau_I \cdot \nu_{AD} \quad (13)$$

Hence, for the rate of advance of the size of the colmatation zone (divided on $\Delta \tau_I$):

$$\frac{dl(\tau)}{d\tau} = -k_B \cdot \frac{\rho_{con}}{\rho_{sed}} \cdot \left. \frac{\partial C_B(x,\tau)}{\partial x} \right|_{x=R_S} \cdot \frac{\nu_{AD}}{(1 - \varepsilon_{sed})}. \quad (14)$$

We receive:

$$\frac{d[l(\tau)/\delta_{con}]}{d[\tau \cdot k_B / \delta_{con}^2]} = K_\rho \cdot \left. \frac{\partial [C_{B.o.} - C_B(x,\tau)]}{\partial (x/\delta_{con}) \cdot C_{B.o.}} \right|_{x=R_S} \cdot \frac{\nu_{AD} \cdot C_{B.o.}}{(1 - \varepsilon_{sed})}. \quad (15)$$

Let us introduce dimensionless variables of the form:

$$\bar{x} = \frac{x}{\delta_{con}}; \theta_B = \frac{C_{B.o.} - C_B(x,\tau)}{C_{B.o.}}; F O_m = \frac{k_B \tau}{\delta_{con}^2}; L(F O_m) = \frac{l(\tau)}{\delta_{con}}. \quad (16)$$

We present equation (18) to a dimensionless form. For this:

- a) we multiply both parts of the equation on $\delta_{con}^2 / \delta_{con}$;
- b) we divide both parts by k_B ;
- c) we enter the value of the density coefficient: $K_\rho = \frac{\rho_{con}}{\rho_{sed}}$.

And finally:

$$\frac{dL(F O_m)}{dF O_m} = K_\rho \cdot C_{B.o.} \cdot \left. \frac{\partial \theta_B(\bar{x}, F O_m)}{\partial \bar{x}} \right|_{\bar{x}=\bar{R}_S} \cdot \frac{\nu_{AD}}{(1 - \varepsilon_{sed})}. \quad (17)$$

Or another recording:

$$\frac{dL(F O_m)}{dF O_m} = K_{\rho c} \cdot \left. \frac{\partial \theta_B(\bar{R}_x, F O_m)}{\partial \bar{x}} \right|_{\bar{x}=\bar{R}_S} \cdot \frac{\nu_{AD}}{(1 - \varepsilon_{sed})}. \quad (18)$$

Here: $K_{\rho c} = K_\rho \cdot C_{B.o.}$

We consider and graphically illustrate some special cases.

1. Physical-mechanical and mass-conducting characteristics of the material remain unchanged during the process: the main such characteristics in this case are the coefficients of porosity and density of concrete and sediment materials, as well as the coefficient of mass conductivity k_B (straight 1 of Figure 2).

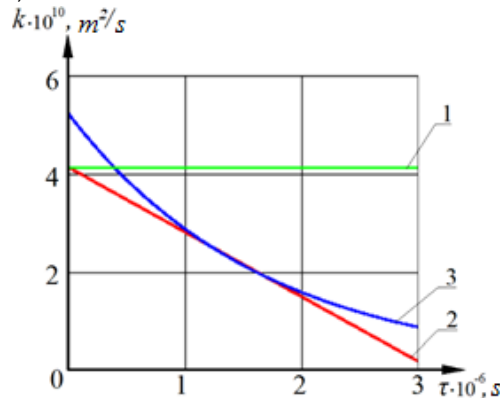


Figure 2. Particular cases of changes in the mass conductivity coefficient k_B in the process of colmatation: 1 – no change in time; 2 – change by linear dependence; 3 – change by exponential dependence

The integration of equation (18) in the processes from zero to the current value F_{O_m} and from zero to $L(F_{O_m})$ gives the law of promotion of the colmatant layer in the pores of the concrete at constant values of the coefficient of mass conductivity:

$$L(F_{O_m}) = K_{\rho c} \cdot \frac{\partial \theta_B(\bar{R}_x, F_{O_m})}{\partial \bar{x}} \cdot \frac{v_{AD}}{(1 - \varepsilon_{sed})} \cdot F_{O_m} \quad (19)$$

2. It is experimentally established that the coefficient of mass conductivity of the material in the solid phase decreases sharply during the process [23]. These data can be approximated by linear or exponential dependencies of the form:

$$k_B(\tau) = k_{B0} \cdot (1 - A_0 \tau), \quad (20)$$

$$k_B(\tau) = k_{B0} \cdot A_1 \cdot \exp(-B_1 \tau). \quad (21)$$

– For linear dependence expressions (18) and (19) are converted to view:

$$\frac{dL(F_{O_m})}{dF_{O_m}} = (1 - \hat{A}_0 F_{O_m}) \cdot \frac{\partial \theta(\bar{R}_k, F_{O_m})}{\partial \bar{x}} \cdot \frac{v_{AD} \cdot K_{\rho c}}{(1 - \varepsilon_{sed})}, \quad (22)$$

$$L(F_{O_m}) = \frac{\partial \theta(\bar{R}_k, F_{O_m})}{\partial \bar{x}} \cdot \frac{v_{AD} \cdot K_{\rho c} \cdot F_{O_m}}{(1 - \varepsilon_{sed})} \cdot (1 - 0.5 \hat{A}_0 F_{O_m}), \quad (23)$$

Here:

$$\hat{A}_0 = \frac{A_0 \cdot \delta_{con}^2}{k_{B0}}. \quad (24)$$

– For exponential dependence expressions (18) and (19) take the form of:

$$\frac{dL(F_{O_m})}{dF_{O_m}} = A_1 \cdot \exp(-\hat{B}_1 F_{O_m}) \cdot \frac{\partial \theta_B(\bar{R}_k, F_{O_m})}{\partial \bar{x}} \cdot \frac{v_{AD} \cdot K_{\rho c}}{(1 - \varepsilon_{sed})}, \quad (25)$$

$$L(F_{O_m}) = \frac{\partial \theta_B(\bar{R}_k, F_{O_m})}{\partial \bar{x}} \cdot \frac{A_1 \cdot K_{\rho c} \cdot v_{AD}}{\hat{B}_1 \cdot (1 - \varepsilon_{sed})} \cdot [1 - \exp(-\hat{B}_1 F_{O_m})]. \quad (26)$$

Here: $\hat{B}_1 = \frac{B_1 \cdot \delta_{con}^2}{k_{B0}}$.

As an example, some results of calculations on the obtained expressions are shown in Figures 3-6.

Figure 3 shows how the collation rate, $\frac{dL(F_{O_m})}{dF_{O_m}}$, and the thickness of the colmatant layer, $L(F_{O_m})$, change from the mass transfer Fourier criterion, F_{O_m} , and the porosity of the sediment layer, ε_{sed} , while the mass conductivity coefficient is assumed to be constant ($k_{B0} = 4.11 \cdot 10^{-10} \text{ m}^2/\text{s}$), and the calculations were carried out in terms of (15) and (17).

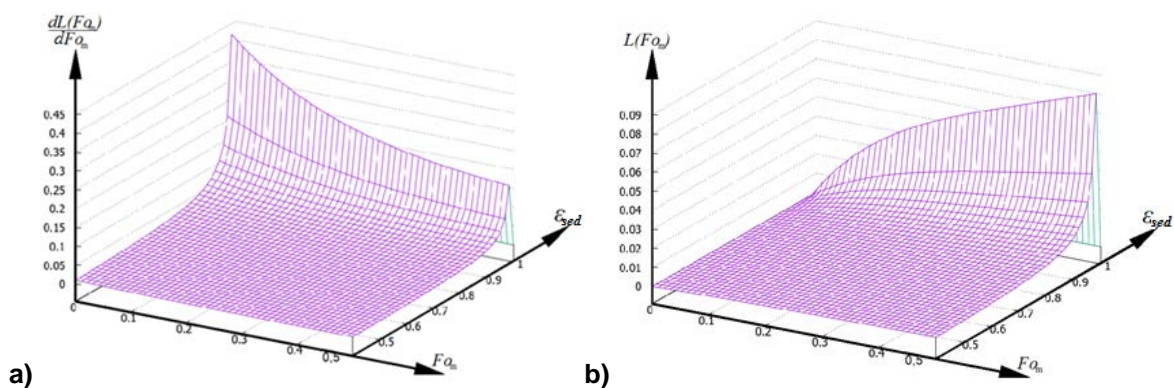


Figure 3. The dependence of the colmatation rate, $\frac{dL(F_{O_m})}{dF_{O_m}}$, (a) and the thickness of the colmatant layer, $L(F_{O_m})$, (b) from the mass transfer Fourier criterion, F_{O_m} , and the porosity of the sediment layer, ε_{sed} , at a constant value of the mass conductivity coefficient ($k_{B0} = 4.11 \cdot 10^{-10} \text{ m}^2/\text{s}$)

Figure 4 illustrates how the speed of colmatation, $\frac{dL(F_{O_m})}{dF_{O_m}}$, and the thickness of the colmatant layer, $L(F_{O_m})$, change from the mass transfer Fourier criterion, F_{O_m} , and the porosity of the sediment layer, ε_{sed} , but unlike Figure 3, the mass conductivity coefficient changes linearly (inclined line 2 of Figure 2).

But Figure 5 presents the graphical results of calculations of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, and the thickness of the colmatant layer, $L(Fo_m)$, from the mass transfer Fourier criterion, Fo_m , and porosity of the sediment layer, ε_{sed} , at the coefficient of mass conductivity of the material in the solid phase sharply decreasing in time of the process, for calculations its values are approximated by exponential (curve 3 Figure 2) dependence.

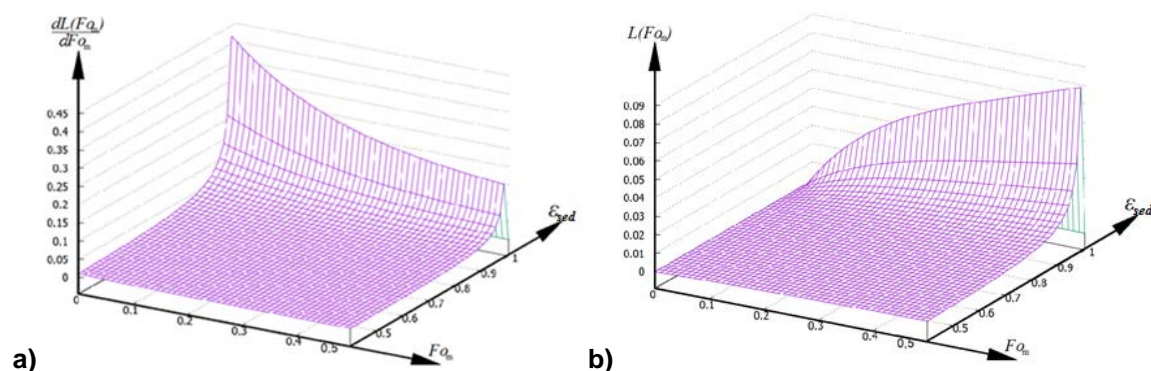


Figure 4. The dependence of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, (a) and the thickness of the colmatant layer, $L(Fo_m)$, (b) from the mass transfer Fourier criterion, Fo_m , and the porosity of the sediment layer, ε_{sed} , when the mass conductivity coefficient changes according to the linear law

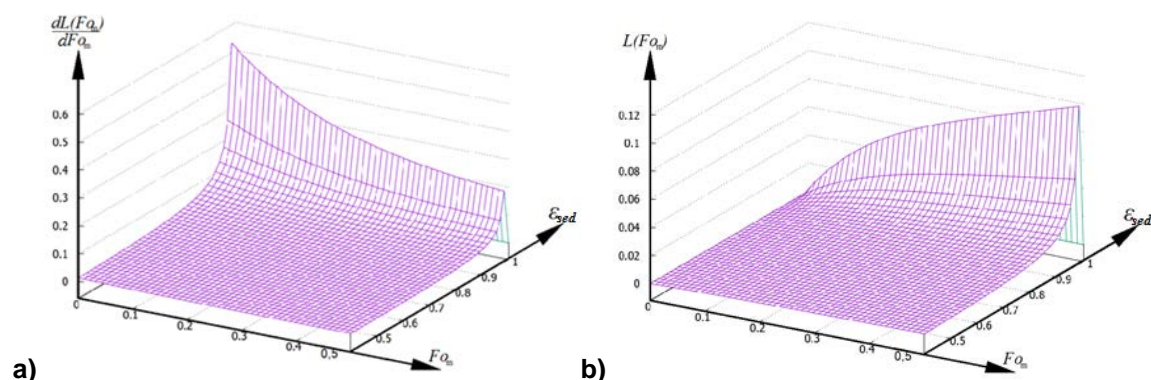


Figure 5. The dependence of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, (a) and the thickness of the colmatant layer, $L(Fo_m)$, (b) from the mass transfer Fourier criterion, Fo_m , and the porosity of the sediment layer, ε_{sed} , when the mass conductivity coefficient changes according to the exponential dependence

The obtained graphic dependences show that the intensity of the colmatation process decreases, and also illustrate a significant decrease in the intensity of the process with a slight decrease in the porosity of the sediment layer (from 1 to 0.9).

To demonstrate the influence of the coefficient of mass conductivity we will present the profiles of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, and the thickness of the colmatant layer, $L(Fo_m)$, from the mass transfer Fourier criterion, Fo_m , at the same value of the porosity of the layer of sediment, $\varepsilon_{sed} = 0.5$, for each particular case (Figure 6). Here, curve 1 shows the results of calculations for a time-constant mass conductivity coefficient; curve 2 shows the change in linear slope dependence; and curve 3 shows the change in exponential dependence.

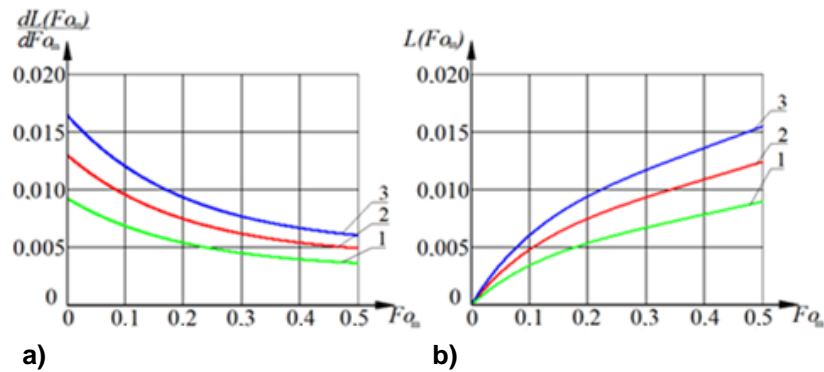


Figure 6. The dependence of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, (a) and the thickness of the colmatant layer, $L(Fo_m)$, (b) from the mass transfer Fourier criterion, Fo_m , when the porosity of the layer of sediment $\varepsilon_{sed} = 0.5$, when the mass conductivity coefficient: 1 – constant ($k_{B0} = 4.11 \cdot 10^{-10} \text{ m}^2/\text{s}$); 2 – changes according to the incline linear dependence; 3 – changes according to the exponential dependence

Figure 7 shows the profiles of the dependence of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, and the thickness of the colmatant layer, $L(Fo_m)$, from the mass transfer Fourier criterion, Fo_m , when the porosity of the layer of sediment $\varepsilon_{sed} = 0.5$, at a variable mass flow value, $\frac{\partial \theta(\bar{R}_k, Fo_m)}{\partial \bar{x}}$. Profiles show that over time there is a weakening of the mass flow which obviously is connected with an increase in the colmatant layer. The speed of colmatation is also reduced due to the fact that the layer of colmatant partially or completely clogged pores and prevents the further penetration of the aggressive environment deep into the concrete.

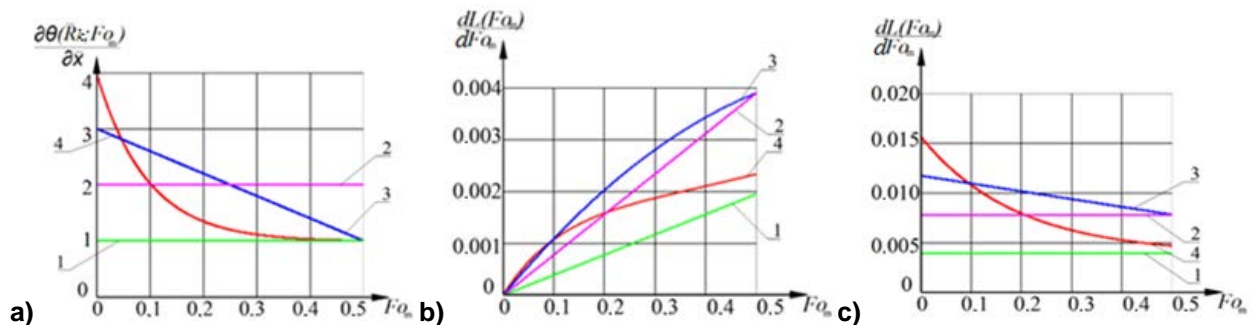


Figure 7. The dependence of the colmatation rate, $\frac{dL(Fo_m)}{dFo_m}$, (b) and the thickness of the colmatant layer, $L(Fo_m)$, (c) from the mass transfer Fourier criterion, Fo_m , when the porosity of the layer of sediment $\varepsilon_{sed} = 0.5$, when the value of the mass flow (a), $\frac{\partial \theta(\bar{R}_k, Fo_m)}{\partial \bar{x}}$: 1, 2 – constant; 3 – changes according to the incline linear dependence; 4 – changes according to the exponential dependence

4. Conclusions

1. The presented model of colmatation allows to predict the corrosion rate of cement concrete considering the movement of the front of colmatation and the thickness of the colmatant layer.
2. Mathematical modeling gives the chance to use the phenomenon of a colmatation of concrete pores to prevent the development of corrosion processes in further experimental studies.
3. Graphic dependencies show that the rate of colmatation of concrete pores during corrosion is slowed down over time, which is associated with an increase in the thickness of the colmatant layer. Due to the pore colmatation, the corrosion of concrete is inhibited, since penetration of the aggressive medium is difficult.

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