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Nomination of Prof. Dr hab. eng. Eugeniusz Krasowski to the degree of "Honored doctor of KNUCA"

According to the decision of the Academic Council dated on March, 25, 2016 (Protocol Nr. 42) Prof. dr hab. eng. Eugeniusz Krasowski was nominated to the degree of "Honoured doctor of KNUCA" for his significant contribution into development of scientific, educational and cultural relationship between the Polish Academy of Science and Kyiv National University of Construction and Architecture.

Eugeniusz Krasowski is a commission chairman on automotive and energy engineering in agriculture of Lublin Department of the Polish Academy of Science. He is the author of about 500 scientific tractates on engineering construction, on research and energy saving equipment and machines. He is also an initiator of the annual scientific and technical conferences such as MOTROL, ENERGIA, which conjointly have been held in both Po-

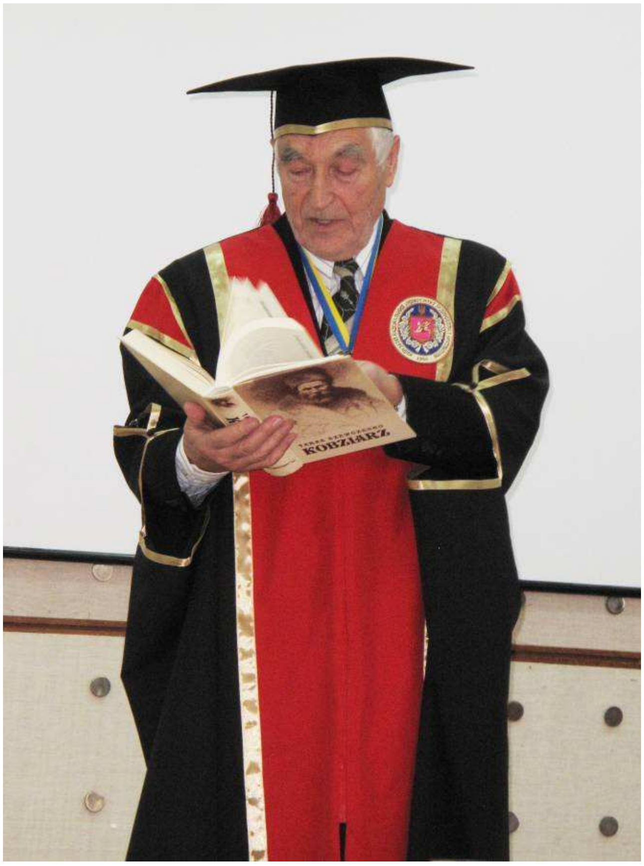
Diploma of "Honored doctor of KNUCA"

Friendly conversation

land and Ukraine since 1997 also with the participation of our University experts. Eugeniusz Krasowski is a Chief Editor of the international scientific magazine “Motrol” (since 1997), “Teka” (since 2001), “Econtechmod” (since 2013), which are included in the top list in worlds special literature, also an associate editor of the international scientific production magazine “Underwater Technology” created in KNUCA in 2015.

Eugeniusz Krasowski was honored with awards and medals and also was elected an honorary doctor of several Universities in Ukraine in recognition of his input to the Ukrainian science and education.

In 2013 Kyiv National University of Construction and Architecture and the Polish Academy of Sciences signed a cooperation agreement in the field of publishing, exchange of experience among experts of related fields, joint educational activities in scientific and educational spheres.



Authorial editions

Greeting of Rector KNUCA

According to this Agreement applicants and experts of tour University have the opportunity to be published in scientific journals and magazines of the Polish Academy of Sciences. Currently there were over 40 articles of KNUCA employees already published in 6 editions of Polish magazines. The joint technical conferences take place under the patronage of the Polish Academy of Science and four professors pf KNUCA Mikhailo Sukach (2010), Petro Kulikov (2014), Vitaliy Ploskiy (2015), Ivan Nazarenko (2015) were elected foreign members of the Lublin Division of the Polish Academy of Science.

According to the Agreement with the chief editor of «Motrol» our University was been delegated powers of Polish Academy of Sciences on the development of one of its eight annual issues. Over the last two years more than 500 pages of articles on construction topics in English were edited and published. These articles were written by our employees.

Eugeniusz Krasowski not only an expert in Technical Sciences but he also is a famous publisher of translations of Ukrainian poetry. Thus, due to his assistance the full translation into Polish of "Kobzar" of Taras Shevchenko and "The Aeneid" of Ivan Kotlyarevskyi were published. These books were presented to the museum KNUCA together with other books of the author. Mr. Eugeniusz Krasowski has elicited applauses from the audience having singed Ukrainian songs during his speech at the Academic Council!

Congratulations to Professor Eugeniusz Krasowski on this outstanding event, wishes of good health and all success!

Associate Editor of Journal Motrol,
Prof. ScD eng. Mykhailo Sukach

The Second International Scientific-Practical Conference "Underwater Technology, 2016" was held

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Abstract. The Second International Scientific Conference "Underwater Technology, 2016" dedicated to the 100th anniversary of corresponding member of NAS of Ukraine Yu. Vetrov was held in Kyiv National University of Construction and Architecture from 19 to 21 April. Already traditionally the problems of the water influence on the environment and innovative technologies were considered at it.

Key words: conference, underwater technology, water influence, environment

Over the past year the list of the organizers and co-organizers of the conference was greatly expanded. First of all there were the Ministry of Education and Science of Ukraine, Kyiv National University of Construction and Architecture, Polish Academy of Sciences (Representation in Kyiv), five leading institutes of NAS of Ukraine, Kyiv universities, Nikolaev, Dnipro, Kharkiv. KNUCA rector prof. Petro Kulikov, the vice-chairman prof. Mykhailo Sukach, Director Stacja Naukjwa w Kijowie PAN (Poland) prof. Henryk Sobczuk, President of the Academy of Ukraine prof. Ivan Nazarenko were included to the organizing committee (Fig. 1).

The Scientific Committee were headed by prof. Mykhailo Sukach; the vice-chairman, academician of NAS of Ukraine professor Victor Grinchenko – director of the Institute of hydromechanics NAS of Ukraine; the vice-chairman, Prof. dr hab ing. Carsten Drebenstedt – Dean Technische Universitat Bergakademie Freiberg (Germany); the vice-chairman, prof. Vladimir Blintsov – vice-rector for scientific work of the National University of Shipbuilding named after academician Makarov. The International Council consisted of representatives from 14 countries – Sweden, Poland, Canada, Germany, Israel, the Czech Republic, Hungary, Slovenia, the Virgin Islands and others.

The task of the international conference – deepening the integration of Ukrainian and foreign experts and scientific schools of development the theory, equipment and research methods of working processes, the creation of new underwater technology, the practical application of innovative energy-saving and ecologically friendly technologies in construction, search engine and mining works, environmental protection and other sectors of industrial activity.

It was the contest to the best scientific and practical work among the professionals and students in the nominations: "Presentation", "Innovation Project", "Publish". There were considered the original ideas and suggestions, innovative solutions and creative projects in the field of underwater technologies. During the conference the participants had an opportunity to present their scientific achievements and there was the poster area for exhibition designs.

Fig. 1. Invitation and work program

The participants of the conference received the greetings from KNUCA rector Petro Kulikov and from vice-rector for scientific work and international relations Vitaliy Ploskiy. Director of the Representative office of the Polish Academy of Sciences in Kiev prof. dr hab. Henryk Sobczuk addressed the audience with warm words about the importance of collaboration between scientists from Ukraine and Poland and wished the creative inspiration and fruitful work. President of the Building Academy of Ukraine Ivan Nazarenko told on the status and prospects of building education in modern conditions. Professor Mykhailo Sukach stressed the importance and prospects of transfer of innovative technologies and presented the program design and development of mineral resources of the World Ocean (Fig. 2).

Fig. 2. The opening of the Second International Scientific-Practical Conference "Underwater Technology, 2016"

Vice-rector for scientific work of NUS, named after admiral Makarov, professor Vladimir Blintsov attracted the audience's attention on the modern problems of development the underwater robotics in Ukraine and presented the NUS specialists' projects, that already applied and may be useful in the future. It is very important the question of communication between the banks of large rivers and extended water ponds. Docent of NTUU Kyiv Polytechnic Institute Gennady Gayko and head of the department of KNUCA prof. Petro Zakharchenko substantiated the possibilities of building tunnel junctions across the Dnieper River. Interesting innovation projects and prospects of the underwater Urban at the beginning of the XXI century were presented by the doctoral student of KNUCA Ludmila Ruban, whose report was enthusiastically listened both by experienced professionals and students (Fig. 3).

At the plenary session prof. Alexander Bezverkhy and Victoria Kornienko (Institute of Mechanics of NAS of Ukraine) also made a speech about the fluctuations of the buoy-moored systems of barrage on the waves. PhD Yuri Stelmahov (international non-governmental humanitarian and environmental organization "Inter-Chernobyl") introduced the project of the elevated road "Kapvey" and Dmytro Kokarev (Solar Energy System Amkortek-Ukraine, Israel) brilliantly presented the innovative energy-saving technologies and equipment for heating water.

Several presentations were planned as on-line-conference by using skype-communication (representatives KNURE prof. Andrew Tevyashev, Olga Matvienko, Vladimir Kobzev al., Alexander Kobzar from UkrNDPItsyvilbud, Oleg Primachenko, Nicholay Harnytskyy from Intersectoral re-

Fig. 3. Participants of conference

search and technological collective enterprise "Lana", Kyiv). Unfortunately, the slow speed of Internet connection and a small traffic were not fully allowed to meet the needs of presenters and audience interest.

The guests from the National Transport University Alexander Hrodetskyy, Alexander Gordiychuk, Kyi Danyleyko, Marya Slyzka started the work of section meetings with the interesting projects "Tourist submarine bathyscaphe", "Underwater Research Station," "Modular underwater vehicle tunnel" (curator - head of the department of computer, engineering graphics and design, doctor of technical sciences Nicholay Kuzminets). Julia Ulyanovska (University of customs and finance, Dnepropetrovsk) and Andriy Dmytrenko (LLC "PROINFO") were concerned about "Using artificial neural networks in today's information technology forecasting", Alexander Budya (KUTEL, Kyiv) spoke about "Water-information centres as the means of effective tourism activities" and Sergii Bilyk (KNUCA) – «Determination of critical load of elastic steel column based on experimental data».

National University of Shipbuilding presented the report of the postgraduate students and teachers Alexander Klochkov, Andrew Voytasyk and Andrew Sirivchuk. The doctoral student of the National University "Lviv Polytechnic" Alexander Blintsov together with the postgraduate student Victor Korytskym took care of "Architecture and constructive types of self-propelled tethered underwater vehicles with improved handling" and "Modern problems of control self-propelled tethered underwater technological platform".

A number of reports presented from Dnipropetrovsk region – National Mining University (Andrey Bondarenko Andrey Nebatov), Okeanmashenerho (Victor Cook, Vitaly Kuzminskyy Olga Ovchinnikov), Institute of geotechnical mechanics of NAS of Ukraine named after N. Polyakov (Volodymyr Naduty, Valentina Chelyshkina, Sergey Kostyrya).

The most numerous group of speakers was from Kyiv National University of Construction and Architecture, postgraduate students and doctoral students of the architectural faculty Nicholay Breyan, Veronica Golovach, Basil Hodos, Julia Smolenka, who presented the "Ecopolis and water innovative technologies". Did not remain without attention the postgraduate students Alexander Cooper, Alex Dvorko, Oleg Skoruk (curator prof. Nikolay Osyetrin) with presentations about the experience in organization of urban traffic.

Some reports were prepared with the expectation of publication in the next issue of the magazine "Underwater Technology". It should be noted an interesting analysis of mangrove ecosystems from the perspective of environmental safety «Assessment environmental safety for mangrove biome» (doctoral student Tetiana Kryvomaz). The postgraduate students of Sumy State University Sergei Kulinich, Natalia Semenova submitted a scientific work "Optimization the control system of hydraulic drives with proportional distributor"; Krishna Kayastha (Hydro Technical Commission, Nepal) – «Development of bell type water well with wide gravel filter».

The direction of the mechanical and electrical engineering covered by 14-th reports of the representatives from the department of building machines and department of machines and equipment of technological processes, KNUCA. We were pleased with the activity of postgraduate students and doctoral students Bogdan Bolily, Alexander Dyachenko, Andrey Zapryvoda, Vadim Zaliznyak, Victoria Korol, Bogdan Matsyuk, Vladimir Martyntsev (curator prof. Ivan Nazarenko). It was also heard a number of presentations, which for various reasons were not stated in the program, but the desire of authors and the need to bring the information to a wide audience encouraged them to dialogue and debate on problematics of the conference.

It was a collective decision to initiate the request to the Kyiv city state administration with proposals to support the objects of underground construction and to develop the strategic plan of Kyiv underground area development (moderators Gennady Gayko, Petro Zakharchenko) and to use the renewable

Ludmila Ruban

Dmytro Kokarev

Fig. 4. Winners of competitions

alternative sources of electricity, heat, solar and mechanical energy located both on rivers and on the coast (moderator Nicholay Harnytskyy).

All speakers that directly took part in the Second International scientific and practical conference "Underwater Technology, 2016" received a certificate of personal participation in the forum with the date and place of approbation the results of scientific work. The most active participants were awarded with Gratitude of the scientific committee of the conference. Thus, KNUCA rector prof. Petro Kulikov and vice-rector for scientific work of NUS named after admiral Makarov prof. Vladimir Blintsov were awarded for the support of young scientists.

Director of the Representative office of the Polish Academy of Sciences in Kiev prof. Henryk Sobczuk and chairman of the automotive and energy department of the Lublin Polish Academy of Sciences prof. dr hab. eng. Eugeniusz Krasowski received the Gratitude for the support of Ukrainian science and international relations. Head of the department of structural mechanics professor. Viktor Bazhenov and head of the department of electroelasticity from the Institute of Mechanics named after SP Tymoshenko NAS of Ukraine professor. Alexander Bezverkhy were awarded with Gratitude for the support of scientific work and professionalism.

According to the decision of the contest commission, the winners 2015/16 were: in the nomination «Presentation» – the representative of the Israeli-Ukrainian company «Amkortec-Ukraine» Dmytro Kokarev; in nomination best "Innovative Project» – doctoral student of the Department of landscape architecture KNUCA Ludmila Ruban; the nomination «Publish» – doctoral student of the Department of labor safety and environmental KNUCA Tatyana Kryvomaz, who awarded the Diplomas (Fig. 4).

Summing up the work, we note that 60 reports from 90 authors were sent to the Second International Scientific and Practical Conference "Underwater Technology, 2016". 56 speakers took part with presentations and discussion, a part of presentations was carried out on-line. The representatives of 18 higher educational institutions, 6 institutions of NAS of Ukraine, 7 production organizations were engaged. Three international and 14 foreign institutions took part directly or as associate members.

It was confirmed the urgency of considered issues about the impact of the water area on the environment and development of innovative technologies, particularly in the fields of industrial and civil engineering. It was supported the initiative of the widest possible highlighting the problems of scientific and practical solutions on the pages of the same magazine, which was recently

Fig. 5. Photo in memory

based. It was established scientific and business contacts between the conference participants and outlined the prospects and ways of further cooperation (Fig. 5). The next event had been planned to prepare and conduct early 2017.

So, thank you all for your attention and participation in the international forum, held on the territory of Kyiv National University of Construction and Architecture. We wish you good health, success and new scientific achievements!

ПРОВЕДЕНА ВТОРАЯ МЕЖДУНАРОДНАЯ НАУЧНО-ПРАКТИЧЕСКАЯ КОНФЕРЕНЦИЯ «ПОДВОДНЫЕ ТЕХНОЛОГИИ, 2016»

Аннотация. С 19 по 21 апреля в Киевском национальном университете строительства и архитектуры прошла Вторая международная научно-практическая конференция «Подводные технологии, 2016», посвященная 100-летию со дня рождения Ю.А. Ветрова. Уже традиционно на ней рассматривались проблемы влияния воды на окружающую среду и инновационные технологии.

Ключевые слова: конференция, подводные технологи, влияние воды, окружающая среда.

The aerobic biological purification of the wastewaters from the organic contaminants (OC) in the aerotanks with the suspended and the fixed biocenosis

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Summary. The mathematical model and calculation methods of biological purification of the waste waters from organic contaminants (OC) in the aerotanks with the suspended (free flowing) biocenosis in the form of the flukes of the active sludge and with fixed biocenosis in the form of the biofilm generated on the surface of the additional loading are presented. The characteristic properties of the modeling and calculation of the purification in the aeration tank mixers and in the aeration tank with plug flow are considered.

Key words: biological purification, organic contaminants, model, aerotank, biofilm.

GENERAL QUESTIONS

In practice at the treatment of urban, domestic and similar in composition wastewaters the most widely are used the methods of the biological purification. The classical technological scheme of such purification is a system of the constructions the main component of which is the bioreactor – aerotank [5, 6, 15]. As is known in the aeration tank the removing (oxidation) of the adsorbed on the floating flakes the active sludge consisting mainly of the microorganisms suspended or dissolved in water organic contaminants (OC) is occurred. Recall that the activated sludge enters in the tank, where is released from the treated water and the part of which goes again for further treatment in the aeration tank. In more details the processes and mechanisms that occur in the biological purification of waste waters system aerotank – tank-regenerator are particularly described in [2, 7, 9, 11, 14].

Depending on the hydrodynamic regime of the liquid flow bioreactors aerotanks are divided into the aerotanks mixers and the aerotanks with plug flow [7, 14, 15]. So in the aeration tank mixer the waste waters, activated sludge and oxygen almost immediately are mixed with each other and therefore the concentration of the microorganisms and contaminants and dissolved oxygen are taken the same around the all reactor volume. In aeration tank with plug flow there is not the mixing and the waste water with activated sludge are moving in the reactor and in a result of the oxidation the concentration of pollutants decreases along the length of the reactor. Especially the decreasing is observed on the initial areas of the reactor. The rate of oxidation of contaminants and according to this the demand in oxygen can be non uniform along the length of the construction and therefore in practice the aerotanks with a plug flow with uniform and non-uniform aeration along the length of construction are used [13, 14].

The made analysis showed that the efficiency of removing of the OC in the aeration tanks especially with the recent increasing demand for quality of the treatment can be significally increased if before suspended biocenosis (activated sludge) to ensure in the volume of the aeration tank the arrangement of additional load in a form of the variety of nets, packing's and so on the surface of which the biofilm with a high concentration of the microorganisms is formed. If the mechanisms of the removing of the OC by the activated sludge are thoroughly researched and presented in particular in [1, 6, 7] then the removing of the OC by the fixed biocenosis in a form of the biofilm so extensively is studying in the filtration of the treatment fluid in the trickling and the submerged filters [3, 6 – 8, 10].

At this the dynamics of the biofilm formation on the surface of the loading and removal mechanisms of the OC by the biofilm are considered and studied noting the significant advantages the removing of the OC by the fixed biocenosis. According to experts such combined biological treatment of waste waters in the buildings with fixed and suspended biocenosis has a number of significant technological advantages and thus their efficiency can be significantly increased [6].

Taking into account of the above the analysis and evaluation of the joint removing of the OC by the suspended and the fixed biocenosis in the aerotanks mixers and aerotanks with plug flow the general mathematical model which is reduced to realization of the following material balance equations written relatively the changes in the concentration of organic contaminants in the aeration tanks L_a is presented. It is assumed that the process of biochemical oxidation is provided by the sufficient oxygen and oxygen is not limiting the kinetics of the biooxidation as suspended and the fixed biocenosis [6 – 8]:

$$\frac{\partial L_a}{\partial t} = D_a \frac{\partial^2 L_a}{\partial x^2} - V\frac{\partial L_a}{\partial x} - R, \qquad (1)$$

$$R = \lambda_a N + \varepsilon R_a - \varepsilon R_c, \qquad (2)$$

where R, R_a, R_c – speeds of the general reaction, utilization of OC by the suspended biocenosis (activated sludge) and extracted substances at the sludge dying off of the sludge respectively; N – stream (transport) of the OC through the surface biofilm for its utilization by the fixed biocenosis (biofilm); L_a – OC concentration in the aeration tank; D_a – diffusion coefficient (dispersion) in the liquid in the aeration tank; $V=Q_a/F$ – the average flow rate in the aeration tank; F – lateral aeration tank area; Q_a – flow rate in the aeration tank; l – working length of the aerotank; λ_a – constructive parameter;

$$\varepsilon = 1 - \frac{W_\delta}{W_a} = \frac{W_p}{W_a}, \qquad (3)$$

W_a – working aeration tank volume; W_p – volume of liquid in aeration tank; W_δ – volume of the given load (packing) with a fixed biocenosis.

In practical calculations sufficiently to consider the equation (1) at the stationary conditions. In dimensionless form it looks as:

$$\frac{1}{Pe}\frac{\partial^2 L_a}{\partial \bar{x}^2} - \frac{\partial L_a}{\partial \bar{x}} - RT = 0, \qquad (4)$$

where $\bar{x} = x/l$, $T=1/V$, $Pe=Vl/D_a$ – known diffusion criterion Peclet.

MODELING AND CALCULATION OF THE AEROTANK MIXER WITH THE SUSPENDED AND FIXED BIOCENOSIS

As are known the general material balance equation of pollutants in the aeration tank mixer has the form [6, 14]:

$$W_p \frac{\partial L_a}{\partial t} = Q_a(L_0 - L_a) - F_{\delta l} N - R_a W_p, \quad W_p = \varepsilon W_a, \quad F_{\delta l} = F_\delta l, \quad Q_a = Q_1 + Q_2, \tag{5}$$

where $F_{\delta l}$ – total surface area of biofilm (load) in the aerotank; F – area of biofilm surface per unit length of aeration tank l.

For practical calculations, equations (5) and (4) when $Pe << 1$ that is at significant values $1/Pe$ can be simplified to look like for ideal aeration tank mixer as:

$$L_0 - L_a - R_3 = 0, \tag{6}$$

where

$$R_3 = \lambda_a N - (R_a - R_c)T_a, \quad \lambda_a = \frac{F_{\delta l}}{Q_a}, \quad T_a = \frac{W_p}{Q_a}. \tag{7}$$

In the future we will use equation (6), (7) for the development of engineering calculations.

Let us consider the following cases in depending on the location of the loading system in volume (area) of the aerotank cases.

1. Elements of load (parkings, nets, etc.) are located throughout the volume (length) of the aeration tank (Fig. 1). In this case, the area $F_{\delta l}$ will be a total surface area of loading in the aeration tank; $F_{\delta n} = \frac{F_{\delta l}}{W_a}$ – specific load area. In this case according to equation (6) removing of contaminants occurs in biofilm by the fixed biocenosis and in liquid aeration tank volume by the suspended biocenosis. To determine the contaminations by the fixed biocenosis it is necessary to determine the flow of pollutions that enter into the biofilm N:

$$N = -D_L \frac{\partial L}{\partial z} = K_L\left(L_a - L|_{z=0}\right), \quad L|_{z=0} = L_\delta, \tag{8}$$

where L, L_δ, L_a – OC concentrations in the biofilm, on the surface of the biofilm and in the aerotank respectively; D_L – coefficient of molecular diffusion in biofilm; K_L – mass-transfer coefficient of the OC in the liquid film.

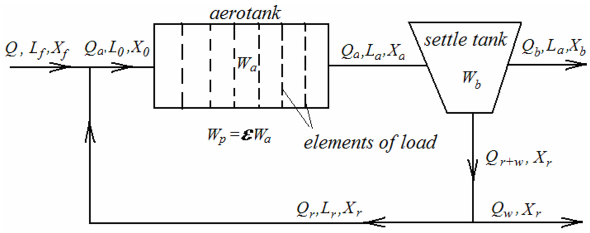

Fig. 1. Balance scheme of the aeration tank mixer with located completely fixed biocenosis

Depending on the type of the velocity of the kinetic reactions which are taken in the biofilm with fixed and suspended biocenosis (activated sludge) in the volume of the aeration tank consider the following variants (technological scheme) removing of OC in general.

As an example consider the case where the reaction rate in the biofilm is taken first order namely:

$$R_L = kL, \quad k = \frac{\mu_m X}{YK_{mL}} = \frac{\rho_m}{K_{mL}}, \tag{9}$$

and in the aeration tank – rate of reaction of zero order namely:

$$R_a = w_a, \quad w_a = \rho_{ma} = \frac{\mu_{ma} X_a}{Y_a}. \tag{10}$$

Here μ_m, μ_{ma} – specific maximum rates of growth of the microorganisms in the biofilm in the aeration tank volume and X, X_a – concentrations of the fixed and suspended microbial biomass respectively; K_{mL} – saturation coefficient (halfamplification); $Y = dX/dL$ – stoichiometric coefficient of the growth of the biomass in the biofilm.

This technological scheme of treatment can be used in particular at the wastewater tertiary treatment by the fixed biocenosis after main treatment by the activated sludge in the aeration tank. The value of the stream of the OC through the biofilm surface N is determined in the result of the solution of the equation which characterizes the removing of the OC by the biofilm formed on the surface of the load material saturated by the microorganisms with concentration X :

$$D_L \frac{\partial^2 L}{\partial z^2} - R_L = 0 \tag{11}$$

with boundary conditions: N at $z = 0$ and $\frac{\partial L}{\partial z} = 0$ at $z = \delta$. This solution was derived in [9] and allows you to determine the change in concentration throught of the biofilm thickness $L(z)$ and what is most important the necessary for further calculations concentration L_δ on the biofilm surface:

$$L_\delta = AL_a, \tag{12}$$

where

$$A = \frac{1+e^{-\varphi}}{\left(1+e^{-\varphi}\right)+\lambda\left(1-e^{-\varphi}\right)}, \qquad \varphi = 2\sqrt{\alpha}, \quad \alpha = \frac{k\delta^2}{D_L}, \quad \eta = \frac{\sqrt{kD_L}}{K_L}. \tag{13}$$

According to (8) the flow of the OC into biofilm will be:

$$N = K_L L_a (1 - A) \tag{14}$$

or [7]

$$N = -D_L \left.\frac{\partial L}{\partial z}\right|_{z=0} = D_L \frac{th\sqrt{\alpha}}{a_0} L_\delta = k_1 L_\delta, \qquad k_1 = \frac{th\sqrt{\alpha}}{\alpha_0}, \quad \alpha_0 = \sqrt{\frac{D}{k}}. \tag{15}$$

Using equation (6) which in this case will looks like as:

$$L_0 - L_a - \lambda_1 L_a (1 - A) - T_a w_a = 0, \qquad \lambda_1 = \frac{F_{\delta l}}{Q_a} K_L = \lambda_a K_L, \tag{16}$$

we may obtain the dependence for determining of the concentration in the aeration tank L_a at the conditions of the removing of the OC by the fixed and suspended biocenosis:

$$L_a = \frac{L_0 - T_a w_a}{1 + \frac{F_{\delta l}}{Q_a} K_L (1 - A)} \tag{17}$$

Taking into account of the recirculation regime and the process of dying the value of the concentrations X_a in the aeration tank in the formula (17) is taken according to next expression:

$$X_a = \frac{X_0}{1 - T_a(\mu_{ma} - b_a)}. \tag{18}$$

The solution of the given technological scheme (see Fig. 1) is made also to the case when the reaction rates in the biofilm and in the aeration tank are taken to the first order namely according to the formula (9) in the biofilm and in the aeration tank to next formula:

$$R_a = k_a L_a, \qquad k_a = \frac{\mu_{ma} X_a}{Y K_{ma}}. \tag{19}$$

The more general case when the reaction rate R in the biofilm and in the aeration tank occurs according to with known nonlinear equation Monod is considered and realized namely:

in biofilm

$$R_L = \frac{\rho_m L}{K_m + L}, \qquad \rho_m = \frac{\mu_m X}{Y}, \tag{20}$$

in aeration tank

$$R_{La} = \frac{\rho_{ma} L_a}{K_{ma} + L_a}, \qquad \rho_{ma} = \frac{\mu_{ma} X_a}{Y_a}. \qquad (21)$$

It will be note that in the equations (20) and (21) the possible influence of inhibiting action of the other substances is not included.

2. Aerotank consists of two parts which we assume are reactors 1 and 2. The first part is a reactor 1 in which removing of the OC is due to the fixed biocenosis that is formed on the mounted load, the second part – the reactor 2 in which removing of the OC is due with a help of the suspended biocenosis (activated sludge) that it works like a typical aerotank mixer (Fig. 2).

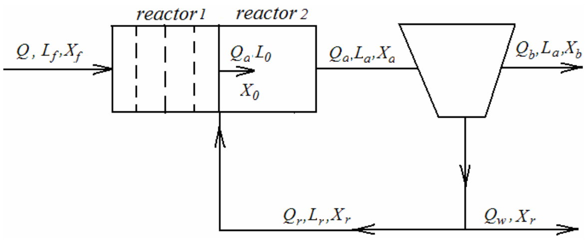

Fig. 2. Balance scheme of the aeration tank mixer with located in the reactor 1 fixed biocenosis

It will be note that in both parts of the aeration tank the reactors are operating under the scheme of the reactor mixer. Then according to the general equation for determining the concentration of the OC at the output of reactors 1 and 2 we will use the next equations:

for reactor 1

$$L_f - L_0 - \frac{F\delta l}{Q} N = 0, \qquad (22)$$

for reactor 2

$$L_0 - L_a - T_a R_a = 0. \qquad (23)$$

That to determine the concentration L_0 at the outlet of reactor 1 more appropriate for the practice will be the solution of the equation (22) at the rates of the reactions in the biofilm of the zero-order and according to equation Monod. In determining the concentration L_a at the outlet of the reactor 2 (aeration tank) it is appropriate to consider the rate of reaction R according to the equation Monod. In this case the reactor 2 is regarded as aerotank mixer. Using equation (23) and obtained before the first case the dependences we may to determine the concentration L_a taking into account of the recirculation of the stream r and output parameters of the reactor 2 including the $T_a = T_{a2} = W_{p2}/Q_a$ and others.

3. As in the previous case aerotank mixer consists of the two parts (reactors) (Fig.3) but in this case the removing of the OC in reactor 1 is due to a suspended biocenosis (sludge) and it works like a normal aerotank mixer but in reactor 2 the removing of the OC is due to the fixed biocenosis on the established here load. Such technological scheme of treatment especially in practical terms will be appropriate according to the modern requirements which demand to more high degree of the purification when in the existing traditional aerotanks the tributary treatment of the waste waters are difficult and uneconomical.

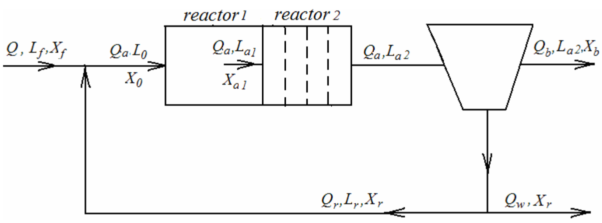

Fig. 3. Balance scheme of the aerotank mixer with located in reactor 2 fixed biocenosis

It will be note that in both parts of the aeration tank the reactors are working as the reactors mixers. According to the technological scheme on the Fig. 3 at the formation of the fixed biocenosis the activated sludge does not participate and passes without change through porous load that is in the volume of reactor 2 may be a slight removing of the OC due to the suspended biocenosis here (sludge) and it is not included. in the reactor 2 is necessary to the methodology developed for the first case (see Fig. 1).

In the result of the solution of the equations (6), (7) taking into account the characteristics of treatment in this technological scheme of the aerotank mixer were obtained the dependences to determine of the concentration of the OC at the output of reactors 1 and 2 taking into account of the effect the most appropriate and possible reaction rates of the removing of the OC. So on the output of the reactor 1 were obtained the dependences of the removing of the OC at the reaction rate of the zero-order and according to nonlinear equation Monod and on the output from the reactor 2 the dependences of removing of the OC at the reaction rates first order and to nonlinear equation Monod are proposed.

MODELING AND CALCULATION OF THE AEROTANK WITH PLUG FLOW WITH THE SUSPENDED AND FIXED BIOCENOSIS

As are known at the conditions of the aeration tank with plug flow the movement of the stream along of the length l of the aerotank with average velocity $\upsilon = \frac{Q_a}{F}$ is taking into account. Since in the real aeration tanks with plug flow the value $\frac{1}{p_e} = \frac{D_a}{\upsilon_e}$ <0,0002 according to [13, 14] then in the engineering calculations to determine the concentration L_a along the stream x the equation (4) can be simplified and written as for ideal aeration tank with plug flow $\left(p_e \to \infty, \quad \frac{1}{p_e} \to 0 \right)$ in the next form:

$$-\upsilon \frac{\partial L_a}{\partial X} - R = 0, \qquad \upsilon = \frac{Q_a}{F} \qquad (24)$$

in which the velocity of the overall realization of the OC utilization by the fixed biocenosis in the view of the biofilm formed on the load and by the suspended biocenosis in the form of the active sludge in the liquid of the aeration tanks has the form:

$$R = \lambda_2 \left(L_a - L\big|_{z=0} \right) - \varepsilon R_a + \varepsilon R_{Cl}, \quad (25)$$

$$\lambda_2 = \frac{F_\delta}{F} K_L, \quad \varepsilon = \frac{W_p}{W_a},$$

where F_δ – the surface area of loading (biofilm) per unit length of aeration tank where is arranged the load; $F = \frac{Q_a}{\upsilon}$ – area of the aerotank; υ – the average flow rate in the aeration tank.

That to solve the equation (24) we must to find a concentration on the surface of the biofilm $L\big|_{z=0} = L_\delta$, in according to the adopted equations of the possible reactions of the removing of the OC in the biofilm and in the aeration tank R_a and dying(selfoxidation) of the sludge R_C. The value of concentration L_δ on the biofilm surface for the reactions of the first order and in the equation Monod can be defined by the formula (12), which may be get by solving equation (11) and for zero-order reaction according to the next formula:

$$L_\delta = L_0 - \frac{\omega_m \delta}{K_L}, \qquad \omega_m = \frac{\mu_m X}{Y} \quad (26)$$

Let us consider the possible technological schemes of the work of the aeration tank with plug flow with the fixed and suspended biocenosis.

1. Elements of the load (parking’s, nets, etc.) are uniformly spaced along the length l of the aeration tank. So in this case the removal of the OC by the fixed biocenosis with the total surface area $F_{\delta l} = F_\delta l$ and the suspended biocenosis (activated sludge) in fluid volume $W_p = \varepsilon W_a$, where $W_a = Fl$ – the total volume of the aeration tanks and

$\varepsilon = 1 - \frac{W_\delta}{W_a}$, where W_δ – the volume of the loading.

Let us consider the case where removing of the OC in the biofilm and in the aeration tank (volume W_p) is occurring according to the reaction of the first order:

$$R_L = kL, \qquad R_a = k_a L_a. \tag{27}$$

After some changes with taking into account to the reactions (27) we may to write the equation (24) in this case as:

$$-\frac{\partial L_a}{\partial x} - L_a(A_* + k_{a*}) = 0, \tag{28}$$

where

$$A_* = \frac{\lambda_2}{\upsilon}(1 - A), \quad k_{a*} = \frac{k_a}{\upsilon}, \quad \lambda_2 = \frac{F_\delta}{F} K_L.$$

In the result of the solution of the equation (28) with the boundary condition at the inlet of the aeration tank $x = 0$, $L_a = L_0$, we will receive dependence for determining of the changes in the concentration L_0 along the length of the aeration tank:

$$L_a(x) = L_0 e^{\tilde{x}} = e^{-B\tilde{x}}, \tag{29}$$

where

$$\tilde{x} = (A_* + k_{a*})x = B\bar{x}, \qquad \bar{x} = \frac{x}{l},$$
$$B = l(A_* + k_{ax})\bar{x}.$$

At the output of the aeration tank at $x = l$, $\bar{x} = 1$, we have:

$$L_a(l) = L_0 e^{-\tilde{l}} = L_0 e^{-B}, \quad \tilde{l} = B. \tag{30}$$

Remind that received solutions are derived at the stationary conditions of the exploitation of the aeration tanks that come quickly enought.

The solution of the equation (24) for the most used in practice event when the removing of the OC in the biofilm and in the volume of liquid in aeration tanks W_p is occurred for more accurate reaction according to the famous equation Monod namely according to the equations in the biofilm R_L (20) and in the volume of the liquid of the aeration tank R_a (21).

The iterative methodic of the calculation to solving of the equation (24) with reactions (20) and (21) the content and the sequence of which is given in [10] was proposed.

In the technological scheme on the Fig. 1 it is possible also the case when removing of the OC by the fixed and the suspended biocenosis occur on the base of various kinetic reactions R, for example, by the suspended biocenosis (activated sludge) for the reaction according to the equation Monod and by the fixed biocenosis (biofilm) for reaction of the first order or vice versa. The calculation of the $L_a(l)$ on the output of the aeration tank is also occurred according to the general equation (30) in this case in which the iterative process is used in the calculation of the reaction occurring to the equation Monod in the volume of the liquid in the aeration tank.

2. Technological scheme aeration tank with the plug flow consists of two parts (reactors 1 and 2), in which in the one of them the removing of the OC is occurred with a help of the fixed biocenosis and in the second by the suspended biocenosis (activated sludge). As mentioned above the features of the removing of the contaminants will depend on their location along the length (in the plane) of the aeration tank in this case. Further consider the possible technological schemes of the aerotank with the plug flow.

1) The reactor with fixed biocenosis (biofilm) in length l_1 located in the first part of the aeration tank (reactor 1, see Fig. 2). In this case the removing of the OC in the reactor 1 is mostly occurred with a help of the fixed biocenosis (biofilm) on the load cells that are uniformly spaced along the length l_1 and is described by the equation:

$$-\upsilon_{a1}\frac{\partial L_{a1}}{\partial x}-\lambda_{21}(L_{a1}-L_1|_{z=0})=0,$$
$$\lambda_{21}=\frac{F_{\delta 1}}{F_1}K_{L1}, \tag{31}$$

where $F_{\delta 1}$ – surface area of the loading (biofilm) per unit length l_1; $F_{\delta l1}=F_{\delta 1}l_1$ – total surface area of the loading in the reactor 1.

The methodic for determining of the change of the concentration L_{a1} in length l_1 as a result we may as a result of the solution of the equation (31) (equation (28) at $k_{a*}=0$) at the boundary conditions $x=0$, $L_{a1}=L_f=L_0$. For the reactions of the first order and according to the Monod equation the solution for determining of the concentration $L_{a1}(l_1)$ at the outlet of reactor 1 will be as:

$$L_{a1}(l_1)=L_0e^{-\tilde{l}_1}, \qquad \tilde{l}_1=l_1A_{*1}, \tag{32}$$
$$A_{*1}=\frac{\lambda_{21}}{\upsilon_{a1}}(1-A_1).$$

The methodic of determining of the parameters A_1 is listed above and $\upsilon_{a1}=\frac{Q}{F_1}$ – average flow rate in the reactor 1 with flow area F_1 and rate of flow Q (see Fig. 2).

Since the effluents with a relatively large initial concentration $L_f=L_0$ come directly in the reactor 1 it would be also appropriate to consider the case of the removing of the OC in reactor 1 with a help of the biofilm according to the reaction of zero order:

$$R_{L1}=w_{L1} \qquad w_{L1}=\rho_{m1}=\frac{\mu_{m1}X_1}{Y_1}. \tag{33}$$

In the result of the solution of the above equation (11) that describes the removing of the OC by the biofilm for determining in this case the concentration $L_{\delta 1}$ we get:

$$L_{\delta 1}=L_{a1}-\frac{w_{L1}\delta_1}{K_{L1}}, \tag{34}$$

where δ_1 – average (estimated) thickness of the active biofilm in the reactor 1.

Then in the result of the solution of the equation (31) with the boundary conditions $x=0$, $L_{a1}=L_0$ and taking into account to the dependences (33) for determining of the changes in concentration along the length x of the reactor on the site l_1 we may get the next dependence:

$$L_{a1}(x)=L_0-\frac{F_{\delta 1}}{\upsilon_{a1}F_{a1}}w_{L1}\delta_1 x. \tag{35}$$

The concentration at the outlet of reactor 1 ($x=l_1$) will be as:

$$L_{a1}(l_1)=L_0-\frac{F_{\delta 1}}{\upsilon_{a1}F_{a1}}w_{L1}\delta_1 l_1. \tag{36}$$

At the possible presence in the reactor 1 the suspended biocenosis with regard to its added action the general equation to determine $L_{a1}(l_1)$ will looks like as:

$$L_{a1}(l_1)=L_0-\left(\frac{F_{\delta 1}}{F_1}w_{L1}\delta_1+w_{a1}\right)\frac{l_1}{\upsilon_{a1}}, \tag{37}$$

where $w_{a1}=\frac{\mu_{ma1}}{Ya_1}Xa_1$, Xa_1 – concentration of the suspended biocenosis in the reactor 1.

In the second part of the aeration tank reactor 2 length l_2 the removing of the OC is due to a suspended biocenosis (active sludge).

In this case in the reactor 2 for a supplying of the suspended biocenosis desired concentration X_{a2} which we assume is formed taking into account the recycling of active sludge and partly possible due to the detachment of the biomass from the biofilm the removing of the OC is described according to (24) the following equation at $\lambda_2=0,\quad \varepsilon=1$:

$$-\upsilon_{a2}\frac{\partial L_{a2}}{\partial x}-R_{a2}+R_{c2}=0. \quad (38)$$

As the processes of dying will be taken into account in determining the concentration X_{a2} the results of the solution of equation (38) will depend on the accepted reaction of the removing of the OC R_{a2} in the reactor 2. In view of the fact that a considerable removing of the OC took place in the reactor 1 that in the reactor enters partially treated waste water the removing of the OC by the active sludge in the reactor 2 will mainly occurs through the actions of the reactions of the first order and according to the equation Monod. In this case the general equation (38) will looks like as:

$$-\upsilon_2\frac{\partial L_{a2}}{\partial x}-k_{a2}L_{a2}=0, \quad k_{a2}=\frac{\mu_{ma2}X_{a2}}{Y_{a2}K_{ma2}}. \quad (39)$$

The solution of equation (39) occurs at the boundary conditions $x=l_1$, $L_{a2}=L_{a1}(l_1)$ and taking into account the possible recycling by the coefficient r_2 we have:

$$L_{a2}=\frac{L_{a1}(l_1)}{1+r_2}, \quad Q_{a2}=Q(1+r_2), \quad X_{a2}=\frac{r_2X_{Y2}}{1+r_2}. \quad (40)$$

Thus in the result of the solution of the equation (39) we obtain the following relationship for determining the change in concentration L_{a2} within the reactor 2 length $l_2=l-l_1$:

$$L_{a2}(x)=L_{a1}(l_1)\cdot e^{-(x-l_1)\frac{k_{a2}}{\upsilon_{a2}}}, \quad \upsilon_{a2}=\frac{Q_{a2}}{F_2}. \quad (41)$$

In the case of $x=l$ in (41) we obtain the dependence of the concentration $L_{a2}(l)$ at the outlet of aeration tank:

$$L_{a2}(l)=L_{a1}(l_1)e^{-(l-l_1)\frac{k_{a2}}{\upsilon_{a2}}}=L_{a1}(l_1)e^{-\frac{k_{a2}}{\upsilon_{a2}}l_2}. \quad (42)$$

As are known the concentration of activated sludge $X_{a2}(l_1)$ includes a certain amount of silt that enters to the reactor 2 from the settling tank through recycling. However in this case from the reactor 1 may enters a certain amount of biomass that is detached from the biofilm, and will also take part in the removing of the OC. In [12] the balance equation is presented that can be used in general case to determine the change in concentration X_{a2} in the aeration tank with plug flow at the conditions of the removing of the OC with a help of the fixed and suspended biocenosis.

In case of the removing of the OC according to the reaction on the base of the Monod equation the equation (38) will looks like as:

$$-\upsilon_{a2}\frac{\partial L_{a2}}{\partial x}-\frac{\mu_{\max 2}L_{a2}}{K_{ma2}+L_{a2}}X_{a2}=0, \quad (43)$$

whose solution at the boundary conditions $x=l_1$, $L_{a2}=L_{a1}(l_1)$ in view of possible recycling coefficient r_2 has the general appearance according to (40):

$$-\frac{\mu_{\max 2}X_{a2}}{\upsilon}(x-l_1)=\left(L_{a2}-L_{a1}(l_1)\right)+K_{ma2}\ln\frac{L_{a2}}{L_{a1}(l_1)}. \quad (44)$$

If takes in the equation (44) $x = l$ then to obtain the dependence which allows to determine the concentration at the outlet of the reactor $L_{a2}(l_2)$ at a known (given) length l_2:

$$l_2 = \frac{\upsilon}{\mu_{\max 2} X_{a2}} \times \times\left(L_{a1}(l_1) - L_{a2}(l_2) + K_{ma2} \ln \frac{L_{a1}(l_1)}{L_{a2}(l_2)} \right). \quad (45)$$

2) As in the previous case the aerotank witht the plug flow consists of two parts (reactors 1 and 2) but in the reactor 1 which is in the first part the removing of the OC is occured due to a suspended biocenosis (activated sludge) which means that it works in the regime of the aeration tank with the plug flow length l_1. In the second part (reactor 2) the removing of the OC is primarily occured due to the fixed biocenosis (biofilm) which is formed on the elements arranged here load. Placing in practice such technological scheme of the aeration tank with the plug flow in our opinion will be most appropriate since the placement in the second part the reactor 2 with the fixed biocoenosis allows significantly to improve the efficiency and quality of the treatment of the waste water, namely to ensure the purification of waste waters to the desired concentration.

Since to the reactor 1 directly enters to the treatment the waste waters of the significant concentration then consider the case of the removing of the OC by the activated sludge according to the reaction the zero order . Supplying of the sludge in the reactor 1 is occured due to recycling of the coefficient r according to the technological scheme shown in Figure 1. So in this case the general equation (38) will looks like as:

$$-\upsilon_{a1} \frac{\partial L_{a1}}{\partial x} - w_{a1}, \qquad w_{a1} = \frac{\mu_{a1} X_{a1}}{Y_{a1}}, \quad (46)$$

where as known

$$\upsilon_{a1} = \frac{Q_{a1}}{F_1}, \qquad Q_{a1} = Q(1 + r_1),$$

$$X_{a1} = \frac{r_1 X_Y}{1 + r_1}, \; L_0 = \frac{L_f}{1 + r_1}. \quad (47)$$

The solution of equation (46) takes at the boundary conditions $L_{a1} = L_0$ at $x = 0$ with the result of that we get:

$$L_{a1}(x) = L_0 - w_{a1} \frac{x}{\upsilon_{a1}}. \quad (48)$$

The concentration at the outlet of the reactor $L_{a1}(l_1)$ will be:

$$L_{a1}(l_1) = L_0 - w_{a1} \frac{l_1}{\upsilon_{a1}}. \quad (49)$$

If according to the above criteria’s in the reactor 1 the removing of the OC by the activated sludge according to the reaction of the first order or the equation Monod that in this case we can to use the solution of the problem obtained for the technological scheme shown in Fig. 1. In this case in the general dependence (24) it is necessary to takes $\lambda_2 = 0$ that to exclude the action of the fixed biocenosis and replace the output parameters of the aerotank on the Figure 1 on the output parameters of the reactor 1.

In the second part of the aeration tank with the plug flow of the reactor 2 length l_2 the removing of the OC is occured mainly due to the fixed biocenosis (biofilm). In this case the features of the treatment in the reactor 2 (with biofilm) located in the second part of the aeration tank will depend on the technological scheme of the action of the reactor 1 with activated sludge. So in the technological scheme in which removing of sludge is occuring directly from the reactor 1 and it does not enter in the reactor 2 it can be assumed and accepted that the removing of the contaminants in the reactor 2 is occured only by the fixed biocenosis (biofilm). If the removing of the sludge from the reactor 1 is not happening and it enters with the waste water to the reactor 2 in this case at first it is necessary to take into account and to evaluate the degree of the removing of the OC through this sludge and at secondly to take into account the presence of sludge and the possible impact of it on the forminf of the structure of the biofilm and determining its parameters.

As a whole it can be assumed that according to the technological scheme in the reactor 2 is occuring predominantly the additional purification of the waste waters particularly treated in the reactor 1. If the additional purification of OC in the reactor 2 is occuring mainly by the fixed biocenosis (biofilm) then taking into account the reaction of the first order or the Mono equation it can be described by the following equation:

$$-\upsilon_{\mathrm{a2}}\frac{\partial L_{a2}}{\partial x}-\lambda_{22}(L_{a2}-L_2|_{z=0})=0, \quad (50)$$

$$\lambda_{22}=\frac{F_{\delta 2}}{F_2}K_{L2},$$

where $\upsilon_{\mathrm{a2}}=\frac{Q_{a2}}{F_2}$, $F_{\delta 2}$ – surface area of loading (biofilm) per unit length l_2; $F_{\delta l_2}=F_{\delta 2}l_2$ – total surface area of biofilm in the reactor 2 length l_2; Q_{a2} – flow that enters in the reactor 2.

In the result of the solution of the equation (50) with the boundary condition $x=l_1$, $L_{a2}=L_{a1}(l_1)$ to determine the changes in the concentration $L_{a2}(x)$ in length x where x varies from l_1 to l we get in general the next dependency:

$$L_{a2}(x)=L_{a1}(l_1)e^{-(x-l_1)A_{*2}}, \quad (51)$$

and to determine the concentration $L_{a2}(l)$ at the outlet of aeration tank (reactor 2) at $x=l$ we have a next dependency:

$$L_{a2}(x)=L_{a1}(l_1)e^{-(l-l_1)A_{*2}}=L_{a1}(l_1)e^{-l_2A_{*2}} \quad (52)$$

If according to accepted technological scheme from the reactor 1 to reactor 2 enters the activated sludge it must also take into account the partial removing of the OC by this silt in reactor 2. At this it is possible to limit this removing as in the case of the fixed biocenosis that is occurred due to the reaction of the first order.

So in this case the removing of the OC is occuring according to the technological scheme with a fixed biocenosis that corresponds the technological scheme of the treatment considered before and shown in Figure 1. In particular to determine the concentration $L_{a2}(l)$ at the outlet of the reactor 2 at the condition that the removing of the OC in it by the fixed and suspended biocenosis is occuring according to the reaction of the first order under (28) and concerning the reactor 2 of the length l_2 the next dependence is proposed:

$$\tilde{l}_2=(A_{*2}+k_{a*2})l_2, \quad k_{a*2}=\frac{k_{a2}}{\upsilon_2}, \quad (53)$$

$$L_{a2}(l)=L_{a1}(l_1)e^{-\tilde{l}_2}, \quad (54)$$

where

$$l_2=l-l_1, \qquad A_{*2}=\frac{\lambda_{22}}{\upsilon_2}(1-A_2),$$

$$\lambda_{22}=\frac{F_{\delta 2}}{F_2}K_{L2}.$$

CONCLUSION

Applying and calculations on the base of the proposed dependencies allow at a given geometrical and other characteristics to assess the impact of various factors on the processes of the treatment in various conditions of their work and make available the most economical and efficient in operating the biological reactor design.

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АЭРОБНАЯ БИОЛОГИЧЕСКАЯ ОЧИСТКА СТОЧНЫХ ВОД ОТ ОРГАНИЧЕСКИХ ЗАГРЯЗНЕНИЙ В АЭРОТЕНКАХ СО ВЗВЕШЕННЫМ И ПРИКРЕПЛЕННЫМ БИОЦЕНОЗОМ

Аннотация. Приведено теоретическое обоснование и методы расчета биологической очистки сточных вод от органических загрязнений (ОЗ) в аэротенках со взвешенным (свободно плавающим) биоценозом в виде хлопьев активного ила и прикрепленным биоценозом в виде биопленки, образованной на поверхности дополнительной загрузки. При этом рассматриваются особенности моделирования и расчета очистки в аэротенках-смесителях и аэротенках-вытеснителях.

Ключевые слова: биологическая очистка, органические загрязнения, модель, аэротенк, биопленка.

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Spatial-Temporal Dimensions and Principles of Sustainable Development of Ecological and City-Planning Systems

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Summary. This work showed results of the research of the methodological foundations for sustainable development of ecological and city-planning systems. This work clarified the applicability of the fundamental law of the sustainable development of open systems – the law of conservation of powers. This work established spatial and temporal dimensions of ecological and city-planning systems "population ↔ environment".

Key words: ecological and city-planning systems, sustainable development, environmental balance, demographic capacity, spatial-temporal dimensions.

INTRODUCTION

Since the beginning of human society, the civilization and development of natural processes are inextricably linked not only historically. These processes are dependent on each other developing by some laws. This understanding of the relationship of nature and mankind as complex systems that evolve on the base of common universal laws receives more and deeper understanding and lighting not only in the natural and social sciences [1, 2, 3, 4, 5], but also in city-planning ones [6, 7, 8, 9, 10].

MATERIALS AND METHODS

The purpose of the study is to determine the fundamental principles and spatial-temporal dimensions of sustainable development of ecological and city-planning systems. During the execution of work we used systematic approach, modeling and comparative analysis. As a basic method we have chosen analogy method, which is a tool for comparative analysis and is widely used in environmental studies.

STARTING POSITION

In the presentation of the modern science, the development of any system is, above all, changes of its state defined by a set of values of the main characteristics of the system [11, 12]. For city-planning system it is, above all, the size of the area of its territory, population, functional and planning structure, social engineering and transport infrastructure [7, 8, 9, 10, 11]. Development is a movement, without which nature cannot exist. At the global scale there is the acceleration of this movement, which is subject to the development of any system, including city-planning development [3, 11, 12, 13].

PURPOSE AND STAGES OF DEVELOPMENT OF ECOLOGICAL AND CITY-PLANNING SYSTEM

City-planning system, which originated as a temporary settlement of people in the "boundless" space, initially had no significant impact on the environment and its changes were barely noticeable. Gradually, the system grew in numbers, expanding geographically, got structurally complicated by functions and combined with other systems like it at the informational level. Today it is a highly complex ecological and city-planning system (ECPS) with excessive anthropogenic pressure on the environment and limited resources [11].

Ecological city-planning system as a set of "population ↔ environment" that creates a new quality, cannot be understood only by studying the properties and states of its components. This system cannot be understood without knowledge of the general laws of formation and development of the world around us.

The development of systems is based on the information programs of cooperation in space and time. "Living organisms, ecosystems, human relations, economic actors, cities are developing... Development is a irreversible, directed, regular change of system based on implementing of the internal mechanisms of self-organization... Self-organization is the process of organizing the internal structure and flow of matter, energy and information passing through a multidimensional system, which is provided with mechanisms of regulation of the system (feedback mechanisms)" [12, p.25].

The mechanisms and strength of self-organization and self-regulation are aimed at streamlining of ecological and city-planning system [9, 10, 11]. The above is subject to the desire to achieve the goal of a particular multi-cycle development of this system – the state of sustainability within a range of environmental (vibrational) balance [4, 5, 6, 11]. At the same time, the development is associated with the ability of the system to self-development – sustainable transformation and change. The self-development cannot be without self-organization and self-regulation, ensuring sustainability conditions – conditions under which the system is able to accumulate the energy required for its further transformation [12, p.26].

At the initial stage of formation and development of city-planning systems, the livelihood of people in the settlements is more governed by the laws of the family relationships. Later these settlements turned into city settlements. Their livelihood was governed by the laws of cooperation – the mutual interaction between people of different professions – a kind of "symbiosis" [4, 5], in which flows of matter, energy and information as a system were more efficiently used. At this stage, the differentiation of professions took place and plants appeared with their further integration on the basis of greater benefit and complementarity "mutualism" [4, 5], creating a more comfortable and safe conditions for the life of the population in cities [1, 3, 6, 11, 12].

DEVELOPMENT POTENTIALS

We know that effective development of system is based on the increase of order in it. "The order is defined as the conditions for sustainable (continuing relatively long period of time) directed changes" [12, p.29]. For order formation in a certain place, this part of the space shall be organized in a certain way at the informational level and internally regulated to give the occurring changes stable directional character. But for this, first of all, the system has to have a certain energy potential, able to bring any changes and movement to life [12, p.31].

As for the potential of ecological and city-planning system. The ecological potential of this system is determined by the climatic conditions and regional resources and is measured by demographic capacity (the ability to accommodate, feed and provide a comfortable living conditions for certain, maximum possible quantity of stable population) [11]. City-planning potential of this system, in addition to social and cultural, engineering and transport potential, is determined by the production potential, which is measured by its economic capacity (the ability to provide the population with jobs for effective and sustainable development of the industrial production in various areas of industrial activity based on resource natural features of the territory and recovery of resources [14].

The measurements of the aforementioned potential to a certain extent are inversely related: with a significant increased of one of them, the value of another indicator can be greatly, sometimes like an avalanche, reduced. The energy difference of potentials violates the ecological balance of the system. However, this imbalance is a driving force of its quantitative and qualitative changes [12, p.32]. The positive direction of the vibrational changes results in conversion processes of development of "population ↔ environment" to a new level of spatial integrity [11, 15].

Development of the system can be interpreted as a process of accumulation and transformation of energy, for that it should be open. The system of "population ↔ environment" as an open system, to support of its sustainable development and restoration of ecological potential uses inflows and the accumulation of solar energy in agricultural products, livestock, forestry and fisheries, minerals, ecophile technologies of energy production. City-planning potential development of the system is due to the production of human activities that create and accumulate wealth in the construction of residential, civil and industrial buildings; roads, vehicles and buildings; buildings of public utilities, engineering preparation, planting and watering of areas; objects of culture, education, science and communication, military and defense industry, and so on. The guarantee of sustainable development of this system is the harmony (mutual coherence) of the aforementioned potential [4, 6, 9, 11, 12].

ECO-PHYSICAL PARALLELS

The spatial ordering of the system provides its structure, which usually refers to the location in space of its individual parts and a set of stable relations between them [12, p.31]. In the city-planning understanding this order is provided by already mentioned structure and infrastructure of city-planning facility [8, 9, 17, 18]. The information ordering of the system provides constant focus organized in space and time of its material and energy flows as the basis for its operation and development [12, p.31]. In city-planning it is provided by a regional policy, strategy and tactics of management, city-planning programs and plans of territories development [7, 8, 18, 19, 20] which, in our study [11, 15], should take into account the fundamental law of open systems – the law of conservation of power (Lagrange, 1788; Maxwell, 1855) [3].

In the plane studied, this law appears to be the law of ecosystem self-regulation [6]. According to this law, in the conditions of "under-population" of the area, the number of population grows, under the conditions of "overpopulation" reduces. The study found that the development of ecological and city-planning system, as well as mechanical and electromagnetic fluctuations (according to P.Ya. Myakishevyy, B.B. Bukhovtsev), has a wave nature [11, 15, 16]. Similarity refers to the natural process of periodic changes (Tab. 1).

SPATIAL-TEMPORAL DIMENSION

According to J. Maxwell, A. Puankare, M. Bor, A. Einstein, R. Bartini, P.G. Kuznetsov, a physical value is universal, if and only if its relationship to space and time is clear [3, p.162]. In city-planning development, the connection with space and time was studied by Z. Hydeon, M.M. Habrel, M.M. Domin, A.M. Plyeshkanovska, V.O. Tymokhin, N.M. Shebek and others. However, identifying of analogies shown in Tab. 1 gave an opportunity to take the next very important step for the development of city-planning science, namely to translate key dimensions of ecological and city-planning system "population

Table 1. The analogy between indicators of ecological and city-planning system (ECPS) mechanical and electrical quantities

Mechanical	Electrical quantities	Indicators of ECPS
mass (m)	inductance (L)	population (P)
coordinate (x)	charge (q)	capacity = maximum number of stable population (C=P_m)
speed (v_x= x’)	current (i = q’)	population dynamics (P’)
acceleration (a_x= x”)	electromagnetic waves in the circuit (q”= $-q/LC$)	growth-rate decline (P”)
elastic force (F_x= $-kx$)	resistance circuit (R)	environment resistance ($1 - P/C$)
spring stiffness (k)	reciprocal capacity ($1/C$)	stiffness of environment ($1/C$)
potential energy ($k x^2/2$)	electric field energy ($q^2/2C$)	potential «electric» energy ($C/2$)[1]
momentum ($mv_x^2/2$)	energy magnetic field ($Li^2/2$)	implemented «magnetic» energy ($P_\Delta P^2/2$)[2]

Notes.

1. Agreed with data of Y. Odum: "Optimal maintenance capacity that can be stored for a long time, despite the whims of the environment, below the theoretical limit, perhaps by 50%" [4, part 1, p.180].
2. May explain some mentioned attractiveness of urban areas.

↔ environment" into the language of universal spatial-temporal [LT] physical quantities [3, p.47].

It is well known that for the city-planning facilities the original [L↔T] values are length [L^1], space [L^2], volume [L^3] and time [T^1] of existence in the environmental area. However, the question arises how the spatial-temporal dimensions are related to the population – an important characteristic of ecological and city-planning system?

According to O.L. Kuznyetsov, referring to the article of R. Bartini "The Relation Between Physical Constants", "all physical quantities are of spatial-temporal nature and can be derived from two variables: length and time" [3, p. 162]. He points to the opportunity to bring all physically measurable quantities from two major ones and present them as a product of integer degrees of length [L^R] and time [T^S], which under various R and S give: dimensionless constants [L^0T^0], geometry objects [L^RT^0], "time" and "frequency and time" measurements [L^0T^S] (Tab. 2) [3, p.162].

It appears that in his time J. Maxwell in his treatise "On Electricity and Magnetism" (1873) set the relationship of dimension of "mass" (with its designation in brackets) with space and time [3, p.151]. According to Maxwell, the spatial-temporal dimension of mass has dimension [L^3T^{-2}] – of volume [L^3T^0] with angular acceleration [L^0T^{-2}]. The "functional" similarities of population to body weight we found out (see Tab. 1) gave an opportunity to present the main indicators of ECPS development in the language of universal spatial-temporal variables (Tab.3).

The most important among the results obtained is a measure of population density and demographic acceleration capacity as a power. These results coincide with the fundamental laws of historical development of O.L. Kuznyetsova: time saving law (display of acceleration of socio-economic development) and net power growth law (expression of cumulation of "free energy" in system "nature – society – man"). The free energy of ECPS development, in this case, is the stock of the demographic capacity. The specified

Table 2. Periodic system of space-time physical quantities by R. Bartini, P.G. Kuznyetsov

T^{-6}					Change of power	Transfer rate of power
T^{-5}		Change of pressure	Surface power	Rate of change of force	Power	Transfer rate of energy
T^{-4}	Change of current density	Pressure	Angular acceleration of weight	Force	Moment of force. Energy	Transfer rate of action
T^{-3}	Current density	Intensity of the electromagnetic field. Gradient	Current. Mass flow rate	Velocity of charge. Pulse	Moment of momentum. Action	Moment of action
T^{-2}	Acceleration	Potential difference	Mass. Number of magnetism and electricity	Magnetic moment	Moment of inertia	
T^{-1}	Speed	Mobility of 2 dimensions	Volumetric flow rate	Rate of volume displacement		
T^{0}	Length. Self-induction	Surface	Volume			
	L^1	L^2	L^3	L^4	L^5	L^6

result is of fundamental importance because it coincides with the little-known definition of sustainable development as "free energy sustainable growth" (UNDP "Sustainable Development of Cities", Moscow, 1999) [3].

In the periodic system of physical quantities in the $L^R \leftrightarrow T^S$ interaction process, symmetry axis is formed, which has symmetrically inverse $L^K T^{-K}$ «axial» invariants having the same dimensions, but different sign. "Axial" invariants differ in speed and are located on levels in the order of growth: Level 1 – $[L^1T^{-1}] = [V^1]$ speed; Level 2 – $[L^2T^{-2}] = [V^2]$ potential difference, "square-speed"; Level 3 – $[L^3T^{-3}] = [V^3]$ current "cub-speed"; Level 4 – $[L^4T^{-4}] = [V^4]$ force; Level 5 – $[L^5T^{-5}] = [V^5]$ power; Level 6 – $[L^6T^{-6}] = [V^6]$ transfer rate of power (see Tab. 2) [3, p.163]. For P.G. Kuznetsov, *LT* system of physical quantities is hierarchy of nested measures – a kind of "matryoshka" measurements, the apex of which is the capacity $[L^5T^{-5}]$, in this case, it is the demographic capacity that characterizes the maximum number of stable population [3, p. 164].

According to the periodic system, formation of speed axis vector is two-stroke transfer from one axial invariant (in our case – the spatial level of ECPS integrity) to another with increasing speed qualities (in this case with the change of possibilities of movement of in space the population, matter, energy and information). During the first stroke of forming, the leading vector in space is determined, in our case, the priority direction and spatial level of territorial development of the city are determined: local – by the resources of surrounding areas or regional, national and global (Global City) – at the expense of resources away from the cities, areas. During the second stroke, the leading vector in time is formed, in our case – is determined by the sequence of city-building regulatory effects, depending on the phase of the cycle of multilevel city development in regional and global dimensions of the environmental space [11, 15]. By analogy with Tab. 2, we built a periodic system of spatial-temporal changes occurring in ECPS (Tab. 4). This table is likely – to provide an opportunity to deeper penetrate into the eco-physical nature of urban and ecological processes of development and

Table 3. Spatial-temporal dimensions of status indicators, direction of changes and the potential of development of ecological and city-planning systems and "population ↔ environment"

Ecological and city-planning index	Units of mesurement or expression	Physical analog	$L^R T^S$ coordinates
Spatially (L) – temporal (T) distances between settlements	Km, hours	path length, travel time	L^1T^0 L^0T^1
The period in question (T)	year, hour	period	L^0T^1
Travel speed (L/T)	km/h	speed	L^1T^{-1}
Population (P)	thous. people	mass	L^3T^{-2}
Capacity – maximum number of stable population (C)	thous. people for a specified period of time and a specific territory	power	$L^5T^{-5}=$ const
Population Dynamics (P')	thous. people/year	current	L^3T^{-3}
The rate of population growth - reduction (P'')	attraction – repulsion	angular acceleration of (deceleration) weight	L^3T^{-4}
Resistance to the environment ($1 - C/P$)		tension of electro-magnetic field	$L^5T^{-5} / L^3T^{-2} = L^2T^{-3}$
Tightening of environment ($1/C$)	1/thous. people	value of the inverse power	$L^{-5}T^5$
The annual potential energy ECPS ($C/2$)		electric field region	L^5T^{-5}
Implemented energy ECPS ($P\cdot{}_{\Delta}P^2/2$)		magnetic field of the city	$L^3T^{-2}\cdot(L^3T^{-3})^2 = L^9T^{-8}$
Area of city, region (S)	thous.km^2	surface, area	L^2T^0
Dynamics of city area, region (${}_{\Delta}S$)	thous. km^2/year	mobility of 2 dimension	L^2T^{-1}
Population density ($\rho=P/S$)	people/km^2	acceleration	$L^3T^{-2}/L^2T^0 = L^1T^{-2}$
Ecological equilibrium space module of life support of a person ($M = S/P$)	km^2/ person	no corresponding physical value now	$L^{-1}T^2$
Comparison of potential in a specific period ($C/P\cdot T$)	possibility of growth	potential difference	$L^5T^{-5}/(L^3T^{-2})\cdot T = L^2T^2$
Reserve of demographic capacity in a particular area for a specified period for development (amount of time) ($C - P\cdot S/T^3$)	thous. people in a particular area for a specified period of time	«free energy» development of a system in specified period of time	L^5T^{-5}
Migration of population (reversible and irreversible) – the number of people who moved in space with a certain speed	thous. people in a particular area for a specified period of time moving in space	«mobility», speed of transfer of power	L^6T^{-6}

Table 4. Spatial-temporal dimensions of change processes of ecological and city-planning systems

T^{-6}						Mobility
T^{-5}			Acceleration of number change		Demographic capacity	
T^{-4}			Rate of population change			
T^{-3}	Changes in population density	Resistance to the environment	Population dynamics			
T^{-2}	Population density. Acceleration of movement	Speed of changes of area	Population.Growth of constructed area			
T^{-1}	Movement speed	Change of area. Active suface	City construction			
T^{0}	Radius of contacts	Area of city, region	Spatial volume			
	L^{1}	L^{2}	L^{3}	L^{4}	L^{5}	L^{6}

take account of the impact of the next speed-hierarchical level of mobility [L^6T^{-6}] that captures the speed capacity. In our case, it analogous may be population mobility, which greatly accelerates the life processes of population and transfers the development of the entire system to a new level of space development.

CONCLUSIONS

1. The growth of population density that has acceleration dimension, causes the gradual expansion of spatial limits of ECPS. The abovedefined reveals the theoretical basis of scientifically proven management of sustainable development of ecological and city-planning systems due to city-planning opportunity to accelerate and slow down urban processes by changing their spatial boundaries and population density.

2. Representing in [LT] dimensions of indicator of changes in population density over time, reveals the physical nature of this indicator as the current density [$LT^{-2}/T = LT^{-3}$]. population dynamic [$L^3T^{-2}/T = L^3T^{-3}$] has physical value of current in ECPS. The above defined indicates the likelihood of a new dynamic characteristics of sustainable development, which detects the oscillating uneven distribution of density changes and the population dynamics, which change creates ripples and surges in business activity in the ECPS.

3. Representing in [LT] dimensions of indicator of changes in population density in three-dimensional space, as [$LT^{-2}/L^3=L^{-2}T^{-2}$], reveals the physical nature of this value as the third derivative of the change in permeability [$L^{-2}T/T^3 = L^{-2}T^{-2}$] over time [3, p.162]. Spatial uneven population density of ECPS is "gravity-magnetic surge" of intensity of land invasion at different levels of spatial integrity. On the one hand, these bursts contribute to the growth of cities (benefits from population concentration and production), on the other – the accumulation of regional differences in the land invasion and "depopulation" regions.

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ПРОСТРАНСТВЕННО-ВРЕМЕННЫЕ МЕРЫ И ОСНОВЫ УСТОЙЧИВОГО РАЗВИТИЯ ЭКОЛОГО-ГРАДОСТРОИТЕЛЬНЫХ СИСТЕМ

Аннотация. Изложены результаты исследования фундаментальных основ устойчивого развития эколого-градостроительных систем. Определена возможность использования фундаментального закона устойчивого развития открытых систем – закона сохранения мощности. Установлены пространственно-временные меры эколого-градостроительной системы «население ↔ среда».

Ключевые слова: эколого-градостроительные системы, устойчивое развитие, экологическое равновесие, демографическая емкость, пространственно-временные измерения.

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New construction and reconstruction of the historic architectural environment in a view of zones of protection the monuments of architecture and town planning

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Summary. Conservation zoning is conducted and zones of protection of the monuments of architecture and town planning of the historic towns are established to protect the monuments and their surroundings, to preserve their compositional value and perspectives of view disclosure, to maintain the traditional character of planning and building of the historic environment. The article shows how the territory of the historical town is divided by the degree of the historical and cultural value of planning, building and landscape. The author analyzes the zones of protection of the monuments of architecture and town planning, reveals their task, shows, how the boundaries of these zones are established. The regime of reconstruction of the historical architectural environment in a view of conservation zoning of the historical city is determined in the article. The regeneration of the historical architectural environment applies to the territory of the monuments, to the complex protection zone and to the protection zones of separate monuments, located outside the historic center. In zones of building regulation is used the reconstruction regime with varying degrees of interference depending on the historical value of the environment around the monument and the remoteness of the site of designing from the monument.

Key words: the historical architectural environment, zones of protection of the monuments of architecture and town planning, reconstruction regime.

INTRODUCTION

Today, before the architects engaged in the restoration and reconstruction of the historical heritage, a very important question of the preservation, modern state and the modern use of the historical architectural environment appears. This question is particularly actual for the historic city centers as the most attractive areas for the investment standpoint. The desire of investors to use the land allocated for new construction in the most expensive parts of the city as much as possible sometimes leads to ignoring the traditional planning, volumetric, spatial and functional features of these areas. In the pursuit of profit and square meters the main compositional principle of historical architectural environment is often not taken into account - the subordination of the new ordinary buildings to the existing historically valuable buildings and dominant monuments, and also the subordination to the typical scale, superficiality and parcellation of facades of buildings which traditionally were formed this town's historical center. It is not a single case, where a new building due to an incorrect selection of volume and number of storeys becomes the cause of disharmony of historical architectural environment, and sometimes destroys all of its composition [15].

Exactly for the protection of monuments and their surroundings, the preservation of their compositional value and perspectives of view disclosure, for keeping the traditional character of planning and building of the historic environment the conservation zoning of the historic towns is held and zones of protection the monuments of architecture and town planning are established.

New construction, restoration or reconstruction of the historic environment should be carried out taking into account these zones of protection of the monuments.

PURPOSE OF WORK

The purpose of this article is to show how the territory of the historic city is divided by the degree of the historical and cultural value of planning, building and landscape, which are the protection zones of the monuments of architecture and town planning in the historic city. How we determine the boundaries of these zones and which are their tasks. The article considers in detail the possible regime of reconstruction of historical environment, based on the protective zoning of the historical city.

MATERIALS AND METHODS

Research on the choice of the appropriate methods of reconstruction and restoration of the historical heritage should be carried out by using the method of graph-analytic historical and architectural analysis and analysis of the current state of the monuments and the environment, the method of comparative analysis, synthesis and theoretical modeling.

RESULTS AND DISCUSSION

Preserving the authenticity of the historical cities, their architectural and town planning monuments is the leading issue in the sustainable development strategy of Ukraine's regions [20].

The protective zoning of the historical city is a town planning means of preserving its historical and cultural heritage. The territory of the historical city by the degree of the historical and cultural value of planning, building and landscape can be differentiated in this way.

1. The most valuable is the area of the historical center (as a complex monument of architecture and town planning) as well as the territories of separate architectural and town planning monuments, which are located outside the historic center.

2. The next in value are the areas that provide the visual perception of the historical center or separate architectural monuments. These areas are adjacent to the historic center or to the territories of separate monuments.

3. Also scientifically valuable are areas in which the archaeological cultural layer was found.

4. Low-value, based on historical and cultural values, are the territories of modern high-rise residential buildings.

5. The territories with disharmonious industrial and warehouse buildings and with landscape, which is destroyed by open development, provide the negative impact to the volume-spatial composition of the historic towns.

Based on this classification of the city territory by the degree of the historical and cultural value, the protective zoning of the historical city is determined. Zones of protection the monuments of architecture and urban planning include:

- the territory of the monument;
- the complex protection zone, which is located within the borders of the historical center and is composed of protection zones of the monuments of architecture and urban planning, which are located in the historic center;

- protection zones of separate monuments located outside the historic center;
- zones of building regulation;
- zones of protected landscape;
- zones of the archaeological cultural layer [16].

Separately should be highlighted:

- the historical and architectural reserves;
- the historical and architectural reserved territory.

sure its optimal visual perception [11].

If the protection zones of separate monuments are crossed or zones are adjacent to each other, the complex protection zone can be established. The complex protection zone can be organized as a zone of special regime of protection and used for all historical center (especially for small towns). This makes possible to preserve the uniqueness and integrity of the whole ensemble of the historic center, not just the separate attractions, which it includes.

Zone of building regulation - is a territory that surrounds or is adjacent to the complex protection zone or protection zone of separate monument of architecture and town planning. It is designed to preserve the traditional character of the buildings of the historic architectural environment, this means preserving the right size and shape for ordinary buildings which are the background of the architectural monuments, which have always been the city dominants and accents [11]. It must ensure a harmonious transition from the buildings of the historic center to the modern buildings.

Zone of protected landscape - is a territory outside the complex protection zone or protection zone of separate monument, designed to preserve the historical landscape surrounding the monument, the unity buildings with nature and visual disclosure of the monument from distant points [11].

Zone of archaeological cultural layer is established in the cities that were founded before the 14-16 centuries, it is the area, where the remains of the cultural layer have been found [16].

It's necessary to allocate another two zones that are protected in the historic city.

The territory of the monument - is the plot where the architectural and town planning monument was located historically and which is necessary for its conservation as the cultural heritage [2].

The protection zone of the monument is the area which is necessary to preserve the dominant in its immediate historical architectural environment and to en

However, they are not in all historic cities. According to DBN 360-92 ** the separate territories in the historic city, which are united by the one planning and volume-spatial composition, which focus the different types of monuments and well preserved historical urban environment, are organized in the historical and architectural reserves and the historical and architectural reserved territories [1].

The historical and architectural reserve - is the complex or ensemble of objects of architectural and town planning heritage, which has significant historical, cultural and artistic value and which is planning and spatially dedicated in the structure of the city [8]. The territory of the reserve is protected by the state. Its land has the historical and cultural destination and more can’t be used any way.

The historical and architectural reserved territory - is the part of the historic city, which was historically formed and planning allocated, which preserved the heritage of architecture and town planning and traditional architectural environment [8]. The historical and architectural reserved territory is protected by the state. Its land has the historical and cultural destination, but is not excluded from the economic use.

According to the State building codes in the zones of protection the monuments of architecture and town planning are the limitations to new building, reconstruction and special regime of usage [2].

How are the protection zones delimitated and what are their tasks?

The territory of the monument - is the plot, which is immediately adjacent to the monument and makes with it the historically formed one unit. This can be:

- the historic core of the town within the fortifications;
- town square with its valuable buildings;
- castle, fortress, monastery;
- the territory of separate architectural monument [16].

The purpose of the allocation of these territories – is the conservation the uniqueness, authenticity and integrity of the monument or the environment that have been preserved to these days.

To establish the borders of the territory of the monument, the existing and lost elements of planning that defined the historical plot of the monument must be taken into account, that are:

- fortifications;
- fences (to the monastery);
- the historical limits of the quarter in which the monument is located;
- surrounding buildings (for town square).

The protection zone of the monument - is the territory, which is necessary for the conservation the architectural monument and its immediate environment, and also for providing its optimal visual perception.

The borders of the monument protection zone are determined by the radius equal to two heights of the monument, but not less than 50m. If the monument is not high, but has a long façade, the borders of the protection zone are determined by the radius of two length of the facade. If the zone of the visual perception of the monument is limited from the closest points, the border of the protection zone may be increased in the direction from which the monument is seen in the most beneficial ways. The protection zone may be an elongated shape. For the town planning dominant the limits of the protection zone can be 350-500 m.

The protection zones for the separate monuments which are not the town planning dominants and lost its historic architectural environment are defined within the limits of the quarters or the plots that are occupied by these monuments.

The regime of using the territory must provide:

1) physical conservation of the monument;
2) the best visual perception;
3) the correct usage;
4) the improvement of the territory.

Typically, in the historic center (especially in small towns) several different monuments are located near to each other. Together they organize the ensemble of the historic center of the small town [12]. The complex protection zone is established for them. In order to determine its borders, exactly the same calculations as for the separate attractions must be done. The radii of the protection zones of separate monuments are combined into a single unit.

Zones of building regulation - are the next in the importance level of the territory of the historical city. These zones are designed to preserve the traditional character of the historic architectural environment. The task of building in these zones is:

1) to keep the dominant value of the monuments;
2) to provide the most favorable visual perception of the monuments;
3) to keep the scale ratio of the dominant and background elements in planning and building. The territory of the monument is always more than the quarter with the ordinary buildings. Space and volumetric size of the monument is always greater than the space and volumetric dimensions of the ordinary building;
4) to preserve the subordination of the forms of the new ordinary buildings to the dominant monuments. The forms of the dominant monuments are always richer than the forms of the ordinary buildings (if the new building must form the background and shouldn’t become a new accent or a new dominant, which is missing in the overall composition);
5) to provide the architectural and planning unity of the new buildings with the historically formed environment by saving the typical compositional devices of building, historic scale and parcellation of facades, traditional materials and color.

How to determine the borders of the zones of building regulation? For separate monuments the zone of building regulation includes the quarters, surrounding the protection zone of the monument. By distance it is equal to a minimum of the two protection zones of the monument. For the complex protection zone the zone of building regulation is at least 200 m from it.

The next by the value is the zone of protected landscape. In the historical cities, especially in the small towns, the historic center and the separate monuments usually have the close connection with the natural environment. Together they form the architectural and landscape complexes. For their conservation it's necessary to establish the zones of protected landscape.

The task of the zones of protected landscape:

1) to preserve the historical landscape, surrounding the monuments;

2) to preserve the historically formed unity of the urban environment with nature;

3) to disclose visually the sights from the distant points (within 1000m-3000m).

The boundaries of the zone are established taking into account the topographical conditions of the area. This zone must include the areas of the landscape where you can enjoy the valuable views of the historic town. Within the zone it's necessary to keep and replay the typical natural environment [16].

The next are the zones of the archaeological cultural layer. For such archaeological monuments as the ancient settlement; earthen walls and canals; mounds; the remains of the foundations of the monuments the archeology protection zones are established as the territory of the monuments in their historical range and their protection zones [16].

The zones of the archaeological cultural layer don't depend on the protection zones of the preserved monuments. They may enter as an integral part to the protection zones of the monuments, to the zones of building regulation or to the zones of protected landscape. In most cases the geometrically exact dimensions of these zones are not possible and they are usually established within the borders of the streets adjacent to them.

According to DBN 360-92 ** for the historical and architectural reserves, on the historical and architectural reserved territory, on the territory of the monument and in the complex protection zone is possible to apply the mode of regeneration of the architectural environment [1]. It's only possible to use the restoration methods. In the zone of building regulation is distributed the mode of reconstruction with different degrees of intervention. You may use as the restoration methods as well the reconstruction methods, depending on the historical value of the architectural environment around the monument and the remoteness of the plot of design from the monument. Further detail for each zone.

1. The territory of the monument.

Within this territory is allowed only the scientific restoration [19], which includes:

- the preservation of planning, building and natural environment that are historically formed;

- the regeneration of the lost elements of planning, construction and natural environment;

- the complete restoration of the monuments and its environment;

- science-based reproduction of the lost elements of the monument (for the square - reproduction of the lost buildings);

On the territory of the monument is prohibited any construction not connected with it restoration and functional adaptation and landscaping the plot. Also is forbidden the laying of transport communications, utility networks, that violate the underground parts of the monuments and the hydrological regime of the territory; installation the overhead transmission lines and transformer points [16]. All architectural and construction works must be performed by the approved restoration project in the relevant authorities of cultural heritage.

2. The complex protection zone.

Designed to preserve monuments in their historical environment, their correct use and create optimal conditions for their visual perception. For this, all territories that are included in the zone of visibility of the monuments should be exempted from high greenery and from low-value disharmonious buildings that hinder the sightseeing. Or their disharmonious influence must be neutralized by reducing the size of high-rise.

On the territory of the complex protection zone should fully preserve the architectural monuments and traditional character of their environment; it means the historical town planning, buildings, landscape, the parcellation of facades, landscaping valuable elements, that are found and are registered during the historical and architectural inventory of the historical area.

According to the state building codes in the complex protection zone only the regeneration of the historical architectural environment, conservation, restoration, scientifically grounded reproduction, fragmentary and complete restoration of the monuments and their surroundings are allowed.

Regeneration - is a method of the town planning restoration of the historic environment with the science-based reproduction of its lost parts and disturbed structural elements, with the adaptation them under the current requirements. It is possible to add or change the functional decision of the historical architectural environment by the point introducing of new buildings with the new functions or new functional adaptation of the existing old buildings. The regeneration of the historical architectural environment allows the following:

1) the preservation of the historic planning and volumetric-spatial structure;

2) the preservation of the historical landscape;

3) recovery the lost elements of planning structure (for example, which often are: town square, walls, fortifications);

4) the restoration or scientifically grounded reproduction of the lost elements of the volumetric-spatial structure (it can be as destroyed dominant or accents, as the elements of background building);

5) the conservation, the rehabilitation, the fragmentary and complete restoration; functional preservation, recovery and adaptation of the architectural monuments;

6) the hidden restoration (works on renewal of the utility networks), which are:

- don’t violate the constructions of the monument;

- don’t give a dynamic impact on the monument;

- don’t violate the soil hydrology;

7) the reconstruction of the road networks (arranging of pedestrian zones, bicycle paths, installation of parking areas for cars and bikes), that can’t violate and can restore the character of the historic environment;

8) the works, associated with planting of greenery and landscaping of the monuments:

- the organization of parks, gardens;

- the installation of exterior lighting;

- the establishment of small architectural forms (signs, urns, benches, shelters, flower beds, stands, showcases, etc.) which are necessary to create quality environment for people [10];

9) the demolition of disharmonious buildings and greenery that violate the traditional character of the historic environment and visual perception of the separate monuments and the ensemble as a whole.

It may be substitution of the industrial plants, workshops, warehouses, that should be deduced from the complex protection zone, and other buildings, that are subjects to demolish, by the new buildings or greenery [2], that:

- don’t conflict with heritage architecture;

- help to preserve and restoration the historic environment;

- don’t prevent the visual disclosure of the monuments.

Thus, the new building in the complex protection zone is possible in the exceptional cases, if it is necessary for the regeneration of the historical environment and does not contradict with the monuments. This is usually the point construction. For example:

- the house-insert, if it is necessary to remove unwanted compositional gap in the ordinary historical building;

- new accent building, which is necessary for the completion of the general composition, and when it is not possible to make scientifically grounded reproduction of the lost accent historic building.

So, for the new building the historical module (volume, building area, height), parcellation of facades, stylistic features, traditional materials and coloring should be sustained. Analysis is done for the existing preserved historic buildings. In accordance with it the modules, typical for background buildings, for accents and for dominant of the given environment are defined. After determining the historical module for the new building is determined the parcellation of the facade and architectural forms, materials and color, which must meet the nearby historic buildings. Before designing of any new building the historical and town planning substantiation must be precede [4, 17, 18]. All documentation which is developed for the regeneration of the territory of the complex protection zone must be agreed with the central executive authority in the field of cultural heritage.

In complex protection zone is prohibited:

1) town planning transformation and restructuring of the territory [19];

2) any new construction, not associated with the regeneration of the environment, restoration and adaptation of the monuments;

3) the construction of transport communications and utility networks that can disturb the underground parts of the monuments and historic buildings and the hydrological regime of the territory;

4) installation the overhead transmission lines, ground transformer points [16], equipment and landscaping that does not meet the requirements of the monuments protection and preservation of the traditional character of the environment.

3. Zones of building regulation.

The regime of use of these territories provides for more active reconstruction of the historical environment and of the buildings. If in the monuments' protection zone only the regeneration of the environment, preservation, rehabilitation, restoration and the science-based reproduction of the monuments and buildings that form the historic environment are allowed, in zones of building regulation could be used more active methods of town planning reconstruction, functional and volumetric reconstruction, namely the renewal and transformation of the environment, partial and complete modernization the historical and modern buildings and also the new construction.

The measures of the reconstructive interventions are defined by the following:

- by the degree of historical and cultural value of the object (the monument of architecture and town planning, the valuable building, the low-value building, the disharmonious building), that is installed with the help of the historical-architectural reference plan [3, 6];
- the degree of preservation of the object and the environment;
- the modern requirements to the object and to the environment;
- the placement of the objects or the plot of the reconstruction in relation to the protection zone of the monument;

In the zones of building regulation are regulated:

- the planning and volumetric-spatial composition of the environment;
- the compositional significance of the monument;
- the compositional devices of building;
- the scale of the planning and buildings;
- the height and length of buildings;
- the character of green spaces.

If the plot of reconstruction is near the protection zone of the monument or in the most valuable part of zone of building regulation, additionally are regulated:

- the architectural coherence of the new buildings with the monuments and historical buildings;
- the parcellation of facades;
- finishing materials and color for the new buildings.

The degree of reconstructive interventions in zones of building regulation provides:

1) the preservation of valuable historical planning and building, green spaces and landscaping, expressive landscape elements;

2) the preservation and regaining of the significance of the monuments in the architectural and spatial organization of the environment [13]. This means, the basic principle of the subordination of the main and secondary is kept. The monument is the dominant, the rest of the buildings – are its background, and so by the planning, by the architectural and functional features everything should be subordinated to the monument or supplement to it;

3) to ensure the best conditions for the visual disclosure of the monuments;

4) to ensure the compliance of all new buildings to the historical scale in the given architectural environments.

In zones of building regulation is allowed:

1) addition the existing planning structure by the new streets, driveways and access roads. The formation of the new streets must be after comparing the historical plans and contemporary planning structure by way of their overlay and determining the optimal locations;

2) the formation of new quarters. Usually on the undeveloped territory or liberated territory from the industrial, warehouse or other disharmonious outbuildings. The form of the quarters is determined after comparing the historical plans and contemporary planning structure by way of their imposition. The size of the new quarters should be less than the size of the territory of the monument, the size of the new buildings in the plan and in the volume – also less than the size of the monument;

3) the new construction, but at the same time, there is a distinct regulation of the new buildings:

- by the location;
- by the devices of planning organization (usually quarterly, dense buildings, perimeter with an inner courtyard);
- by height (in each historical city - in different ways, depending on the height of the monuments and number of storeys of the existing historic buildings);
- by the length of facades (not more than the traditional length of the facade of the historic buildings in this historic city, for the historic small towns usually - 3-4 windows; the multisection typical houses - are prohibited, or sections should be different from each other in height, plastic facade and decor);
- by the scale (according to the established in this historic environment for ordinary buildings, accent and dominant buildings);
- by the nature of the parcellation of facades, the vertical and horizontal (should be close to the historical);
- by the plastic and coloristic decision (can be new forms, new materials, but are similar in coloring and in plastic decision to the historical buildings of the given environment);
- by their functional (new function should not contradict the historical functions, should complement and develop them, should not cause the destruction of the historic environment [14]).

The correct modern functional organization of the historic environment is a very important point in the mode of using the zone of building regulation. What function should be removed as disharmonious and which should be add to improve the quality of the existing architectural environment, actively develop it, but don’t harm in this activity.

From zone of building regulation should be removed the disharmonious industrial and warehouse buildings. This can be done as follows:

- by the conversion of the industrial enterprises; the enterprise is modernized, its area is declining, there is only harmless production, which does not require the large storage facilities and transport load;
- by adapting under a new function with the change of the appearance; the new function should complement the historic town environment based on the chosen direction of the contemporary development of the historic town as a whole;
- by demolition; after the deactivation of the territory (clean from contamination) the recreational, residential or public area should be organized on its place. Creation of the green recreational areas is aimed to balance the microclimatic conditions of the city [9],

to preserve and to improve its environmental situation [7].

If for some reason the disharmonious building can’t be demolished or the full modernization completely does not solve the problem (for example, reduce the altitude), it is possible to make the so-called "green curtain" which visually neutralizes the disharmonious building, separate it from the historic buildings. Exactly the same device is applied if it necessary to separate the historical building from the transit highway, and is not possible to move this highway.

Also it is necessary to "get rid" from the degraded, abandoned and empty territories. There are many, especially in small towns. The degraded areas need revitalization. The empty territories after studying and compiling the historical and town planning substantiation can be built by the new buildings with the necessary functions for the given historic environment or be transformed to recreation.

In zone of building regulation is prohibited:

- the placement of new industrial, transport and storage enterprises that generate the large traffic flows [2]; this requires the expansion of the roads, construction of new interchanges which can violate the intimacy of the historic environment;

- the construction of new highways, bridges, interchanges, which can also damage the traditional character of the historic environment [2].

If it is possible, the transport can set down underground, creating underground solutions with a combination of several types of transport. On the ground level there are only entrances to the underground level, that can be designed as the separate elements (small architectural forms) in the squares or streets, or be located in the new or in the reconstructed ordinary building.

Before making any project of reconstruction of the historical town environment it’s necessary to do the pre-project cycle of researches of this environment [11]. All projects must be consistent with the relevant authorities of protection of the cultural heritage, architecture and town planning.

4. Zone of protected landscape.

The territory of zone of protected landscape can be used:

- for the recreation which carry out works on landscaping;

- for traditional economic activity, that does not violate the landscape and does not require the capital structures construction in this territory [2] (typically for the small historic towns).

In the zone of protected landscape is allowed:

- carry out the works on the strengthening of the river bank, with its modern update and adaptation (such as promenade);

- carry out the works on the strengthening of the slopes [5], their greening, landscaping;

- the preservation of existing individual buildings, if they don’t violate the historical landscape;

- the new construction of the individual residential buildings in that part of the territory where there are the individual buildings, if the new buildings will be not placed on the upper elevations of the slope, and their height will not exceed 7m (2 floors).

All industrial and warehouse buildings should be removed from the zone of protected landscape. There is forbidden:

- the construction of the new buildings with the average number of floors and above;

- the construction of the roads, laying of the utility networks, overhead transmission lines;

- any other construction and earthworks, which are not connected with the protection and restoration of the historic landscape;

5. Zone of the archaeological cultural layer.

The regime of usage is the following:

1) the construction and earthworks are conducted with the permission of the state authorities of protection of cultural heritage and under the supervision of the archaeologist;

2) before the beginning of major construction or excavation in this territories, the archaeological researches must be carried out according to the plans of the construction placement;

3) after the completion of researches, the plot, on which there are the remains of old buildings, must be protected as the monument of cultural heritage; should become the subject for museification [16]. It is prohibited to build on this site.

If the remains of buildings in this territory are not found, after the complete study and by the decision of state authorities for the protection of cultural heritage, this plot is deduced from the zone of archaeological cultural layer. New construction on it is possible only according to the state building codes [1].

Zones of protection are specially allocated to protect the traditional nature of the environment, the architectural and town planning monuments and the ensemble of the historical center as a whole and for the regulation of the new construction and the reconstruction of the historical architectural environment.

CONCLUSIONS

The new construction and the reconstruction of the historical architectural environment should be carried out taking into account the zones of protection of the monuments of architecture and town planning.

The protective zoning of the historical city territory is determined based on the differentiation of the degree of the historical and cultural value of its planning, building and landscape.

The regime of reconstruction and modern use of the separate territory in the historic city depends on to which protection zone it enters. Within the territory of the monument the scientific restoration is only possible; in the protection zone of the monument – is regeneration; in the zone of building regulation – are the renewal and the transformation of the historic environment, depending on the value of the environment and the remoteness of the plot of building from the monument.

Within the new construction for the new building, the historical module (volume, building area, height), the parcellation of facades, stylistic features, traditional materials and color should be conditioned.

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НОВОЕ СТРОИТЕЛЬСТВО И РЕКОНСТРУКЦИЯ ИСТОРИЧЕСКОЙ СРЕДЫ С УЧЕТОМ ЗОН ОХРАНЫ ПАМЯТНИКОВ АРХИТЕКТУРЫ И ГРАДОСТРОИТЕЛЬСТВА

Аннотация. Для защиты памятников и их окружения, сохранения их композиционного значения и перспектив видового раскрытия, сохранения традиционного характера планировки и застройки исторической среды проводится охранное зонирование территории исторических городов и устанавливаются зоны охраны памятников архитектуры и градостроительства. В статье показано, как делится территория исторического города по степени историко-культурной ценности планировки, застройки и ландшафта. Автор анализирует зоны охраны памятников архитектуры и градостроительства, раскрывает их задачи, показывает, как устанавливаются границы этих зон. В статье определяется режим реконструкции исторической архитектурной среды с учетом охранного зонирования территории исторического города. На территорию памятников, комплексную охранную зону и охранные зоны отдельных памятников, находящихся за пределами исторического центра распространяется режим регенерации среды. На зоны регулирования застройки - режим реконструкции с разной степенью вмешательства в зависимости от исторической ценности среды вокруг памятника и удаленности расположения участка проектирования от памятника архитектуры.

Ключевые слова: историческая архитектурная среда, охранные зоны памятников архитектуры и градостроительства, режим реконструкции.

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Conditions of small towns' historic environment formation and development

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Summary. To create competent reconstruction projects in historic urban environment it is necessary to carry out pre-project analysis of formation and development conditions and factors of architectural urban environment of a small town's historical center. Historic environment is viewed as an object of the research, the components of which have been created during a certain historical period of the town's development. The historical period must be characterized by certain evolutionary development patterns. The aim of the historic urban environment redesign is to preserve the town's originality in the process of historical center reconstruction. Taking into consideration the results of preconception studies, it is essential to carry out further research of historical center's values. The article deals with the analysis of the main formation and development conditions of small towns' historic environment.

Key words: continuity principle, historic environment originality, time-layers, forming factors, the evolutionary process.

INTRODUCTION

The architectural experience suggests that numerous reconstructions of historically formed urban center environment results in significant changes of traditional town's space, which has been formed for centuries. The towns are constantly developing and never considered as completely constructed objects. As a result, it is impossible to preserve their genuine historic environment. «The historical center of a small town is considered to be an indicator of the society's evolutionary development, its cultural traditions, taste, spiritual energy, historical memory of the nation. Each stage of the historical process is characterized by a new urban development according to the time requirements. The historic urban areas must be preserved with their inherited «atmosphere» with all the essence and spirit of the past centuries» [13].

One of the most relevant issues today is the problem of a small town's historic center reconstruction. The urban environment is characterized by sporadic development, absence of preservation principles and individual development of the towns as well as the lack of awareness in studying of historic environment morphology on various time stages.

The studying of historic and archive documentation as well as modern urban planning are performed within the framework of the pre-project research of the urban environment [17]. «The required and essential component of the pre-project research in the sphere of historic urban reconstruction is the historic and genetic analysis. It provides studying and contrasting of historical plans, revealing of the most stable structural elements, specific peculiarities of a certain town evolution» [13]. Its main objective is to identify the genetic code of a town [17].

The preservation of originality, individuality, identity and continuity of historic environment of a small town is achieved only under the conditions that architecture is understood as a process of historic environment formation. A research in this sphere is an important, essential and qualitative stage for understanding the process of small towns' historic environment reconstruction.

PURPOSE OF WORK

Under the conditions of reconstruction, small towns' historic environment should be studied from the perspective of its main characteristic features and values, the importance of which is analyzed in the article. These indicators can be used in the process of analyzing small towns' historic environment formation and development in dynamics, its evolution peculiarities, and reasons for existence of its various properties in order to evaluate them properly and to develop the forward-looking master plans.

MATERIALS AND METHODS

Research of small towns' historic environment and its main characteristics should be carried out with using the method of graphic and analytic analysis of the conditions and factors of small towns' historic environment formation and development, the method of comparative analysis and, as a result, the generalization method for drawing up the result recommendations schemes.

RESULTS AND DISCUSSION

Changes and reconstruction of the historic urban environment can be observed on all stages of their evolutionary development. The considerable portion of modern redevelopments of historic towns takes place under the conditions of reconstruction. Reconstruction must be viewed as a principle of urban environment improvement and development, as the new construction objects have an influence on the already formed parts of the town and later can become the candidate reconstruction objects. The historic urban environment reconstruction is closely connected with early layers of the town rather than with the construction of a new town or environment. To evaluate the morphology of transforming environment and understand its further development, it is essential to generalize the conditions of small towns' historic environment formation and development according to the basic characteristics.

A significant role on this stage of research is played by the analysis and importance of the following objectives:

- recognition of town's historical center value;
- recognition of town's historic environment originality;
- application of historical and cultural continuity principles;
- comprehension of town's historic environment formation process in the result of cultural layers with the course of time;
- consideration of factors, which influence town's historic environment formation and development;

The significance of every abovementioned objective warrants their further analysis.

Recognition of town's historical center value

Towns are considered to be the centers of national traditions and continuity principles. They are also characterized by large open spaces, social structure and a way of life, the features, which are not peculiar to cities.

Towns are considered to be historical if they have the longest period of formation and development as well as cultural heritage, in particular architectural [5]. Every «small historical town has its distinct character, determined by its history; level of economic development, industrial arts and trade; people's cultural awareness; natural resources of the vicinity; geographical location; level of communication access; landscape, which creates the town's ground; peculiarities of planning and architecture» [19].

However, the influence of various factors and changes of society demands require the systemic analysis and new approaches to the organization of historic environment of small towns.

Each stage of evolution and transformations of every historic urban environment part, which appear on various stages of historical development, should form the integrated harmonious space. It depends on recognition of this process as a spatiotemporal system.

The main emphasis is put on the historical center, as it is also a cultural, business, religious and commercial center with all its main and important monuments of different periods and styles. The image of every town is associated with the impressions created by its historical center, the «heart» of the town. Each historic environment is characterized by the range of unique peculiarities, which influence the specifics of its research:

- individual character and uniqueness;
- multifunctionality and permanence;
- multiplicity and historical continuity [19].

Recognition of town's historic environment originality

Originality and architectural uniqueness are considered to be the main value determiners of historical town center.

The complex of identifying characteristics, which have been formed in the process of historical development and depend on conditions and factors of urban development as well as the character of evolutionary processes, maintain the town's originality, which is identified as a unique artistic value of every historic urban environment.

«The UNESCO World Heritage Convention (February 5, 2005) declared the necessity of monuments' preservation as well as saving of all social, cultural and historical evidence, traditions and records, which form the construct of a historical town. According to the Convention, heritage authenticity is determined not only by the integrity of material heritage, but also by the preservation of its functions, immediate surrounding, language and other forms of immaterial heritage, spirit and beliefs as well as other inner and outer factors» [13].

Since its formation, historic environment of a small town is characterized by its special «genetic» code, character of a town, which is passed on from generation to generation. This code is defined as originality of a town.

Application of historic and cultural continuity principles

Despite its history and values, constant improvement of the environment, which is based on social, economic, scientific and technical changes, must include such a constituent element as historical and cultural continuity [12]. Historical and cultural continuity maintain the preservation and development of the integrated environment, its identity, distinctive character, originality and value of every historical tow center.

The end of the XIX century was characterized by some changes in architecture, which influenced the formation of historical and cultural continuity.

«The dominant values, which guided the bourgeois-democratic society, were personality instead of class hierarchy; the freedom of choice instead of set rules; variety of behavior patterns and self-expression forms instead of canons of style. The most important change of this period, which is significant for understanding the nature of architecture and urban development, is historical thinking. The modernity was considered as the logical consequence of the past and a motivation for the future» [13].

As a result, historical thinking encouraged the architects and urban development constructors to apply the art of the past. Applying the continuity principle, the architects of the historic urban environment, based on the historic experience, have created many theoretical and practical building patterns, which combined present, past and future.

A. Hutnov gives the following description of this period: «A town is viewed as a process, which takes course in certain spatial environment, but not as an environment by itself or as an inactive special characteristic of this process. The process implies the «socialization» or «humanization» of a town as a design and research object and is considered to be the main distinctive feature of the modern evolution stage in urban development thinking. Earlier the urban planning project dealt with the question of spatial town organization. Today an urban planning architect has to take into account not only space, but also time, which is the most important characteristic feature of the process of town's life-sustaining activity» [11].

The idea of a historical town as an object of heritage was studied and carried out in the projects by the range of architects.

The most outstanding architect of that period was Camillo Sitte (1843–1903). Sitte was the first who started to study a town from the historical perspective in the end of the XIX century. According to his ideology, the first step was to investigate the morphology and typology of the environment and then to offer modern ways and models of its development [22]. His idea of continuity played a significant role in further development of historic towns' principles and environmental protection.

His ideology was supported by the leading architects and theorists. Among them were Raymond Envin (England), Werner Hegemann (Germany), Patrick Geddes (Scotland), Gustavo Giovannoni (Italy), Kevin Lynch (the USA) and the others [11, 8, 6, 21, 18].

Werner Hegemann (1881–1936) investigated the universal character of town formation principles in various countries at different period of historical development. Hegemann described a town as a collage, within which all the components, preserving their authenticity, interact for creating a new conceptual environment, where a town is viewed as a specific physical outcome of the long-term formation process and serves as an architectural statement for its future development [8].

Patrick Geddes emphasized the importance of local values and studied them in connection with architecture. In the book «Cities in Evolution» (1915) about the development of urban environment, the researcher claimed that every generation contributes to the physical space of a city, changing and adding new structures and imparting it with new functions [6].

Gustavo Giovannoni made the greatest contribution into the investigation of historical continuity principle. «He introduced the important principle of necessity to preserve the town's tissue, historically built-up urban environment, which reflects all the time-layers. Within the framework of a new paradigm, a town was considered as the territory, which could be imparted with new functions that had to conform to the town's traditional morphology» [21].

The 70s-80s of the XX century were the period of inobservance to the preservation of traditions and heritage. Kevin Lynch in his books claimed that the historic heritage had to be preserved, but at the same time, people should start a new life on the territory of historical centers. However, this new life must conform to the values of previous historical periods [18].

The wide range of documents and charters on protection and development of historic urban environment are based on the above-mentioned approaches and conceptions.

Comprehension of town's historic environment formation process in the result of cultural layers with the course of time

«The town-planning formation exists not only in space, but also in time. Space is the form of material environmental components existence, which characterizes their properties, structure, co-existence and interaction of the elements. Time designates the town-planning formation period of existence, the succession of condition changes in the process of transformation and development of all material components. The course of time can be clearly observed in formation, and the architectural monuments are considered to be the documentary sources of historical and cultural information prior to corresponding period. Usually the environment of town-planning formations is created and developed during many centuries. The duration of its development, chronological inhomogeneity, connection between formations of different periods and styles are becoming the important features of the environment» [3].

Town's historic environment in the process of its formation and further development is characterized by various changes, which can be defined as certain tendencies of evolution theory. The town-center reconstruction projects must be based on this evolutionary approach. The latter provides the analysis of the environment's long-term development, the designation of initial reasons and conditions of such development, its characteristic periods with specific peculiarities. The genetically conditioned factors of historic urban environment development are preserved.

The town-planning principle of various historic periods reintegration was already discussed during the Brest Colloquium (France, 1983) [2]. The discussion was devoted to the preserved and lost types of town centers during various periods. These types must be analyzed in unity and in terms of urban environment reconstruction. To unite all the chronological periods together in a modern town, it is essential to combine various time samples with definite homogeneity.

Value, significance and intensity of reconstructed environment are defined by various layers of historical periods and by their chronological rate.

«The material basis of historical town-planning formations in temporal dimension is not homogeneous. Constant reconstructions, transformations and redesign have led to numerous built-ups in development, redounded upon streets and squares' planning projects. However, inherited built-ups on the material basis of space frame formations or generated on the course of historical development architectural and stylistic updates of various periods to the design of these formations are considered to be the traces of certain social and cultural processes, historical events; they are the witnesses of history, but only within definite chronological dimension. Consequently, there is a problem of measuring the chronological rate of historically developed spatial frame of formation within the framework of which is appropriate to emphasize the authenticity of its material basis» [20].

Consideration of factors, which influence town's historic environment formation and development

To determine the consistency of town's historic environment formation and development, it is essential to emphasize the factor analysis, which implies the description of factors basing on the role of town-planning during various time periods, the influence and interaction of factors and time dynamics.

The research in this article is also carried out on the materials, which are studied in various related fields, such as history, geography and the others. It requires a comprehensive analysis of the territory [7, 16, 24].

Town's historic environment is based on human activity, demand of society and the way of life, that is why it is constantly changing. It is impossible to stop these changes, as it contradicts the development of the environment in general. An interdiction of changes causes the destruction or substitution of the existing environment. Moreover, in the process of transformation only some stable and relatively permanent elements are preserved.

«N. Hulyanitskiy describes a range of factors, which influence the individual characters of a town and have stable or relatively stable nature. These factors include local natural and climatic conditions, traditional peculiarities of architecture and town-planning techniques. The researcher also singles out national architectural originality, which is considered to be a slowly varying factor. Historical elements of a modern town with valuable architectural heritage should be the natural part of the whole. According to

N. Hulyanitskiy, natural landscape is also an important factor, as its diversity and uniqueness are the basing elements of historical town’s individual character» [10].

Preservation of stable and permanent factors, which are the basis for formation and development of town’s historic environment, is the guarantee of proper comprehension of historic heritage, originality, continuity and settings, which imply transformation of some most permanent elements. As a result, the realization of conditions and factors, which influence the formation and development of town’s historic environment, is possible only under thorough analysis of the interaction between stable and dynamic components. The main forming factor of a town is its historic center, which also includes other factors that influence differently the evolution and reasons of formation of various spatial peculiarities.

All these problems were taken into account when developing the project of reconstruction of the historical center of the small town of Bar in Vinnytska region (Fig. 1). A project envisages creation of architectonically-spatial accents of market, temple and town hall area. They are the center of attraction for citizens, habitants of nearby cities, tourists and unite the historical, cultural, trade, business, recreational, tourist, dwelling and spiritual function of the city.

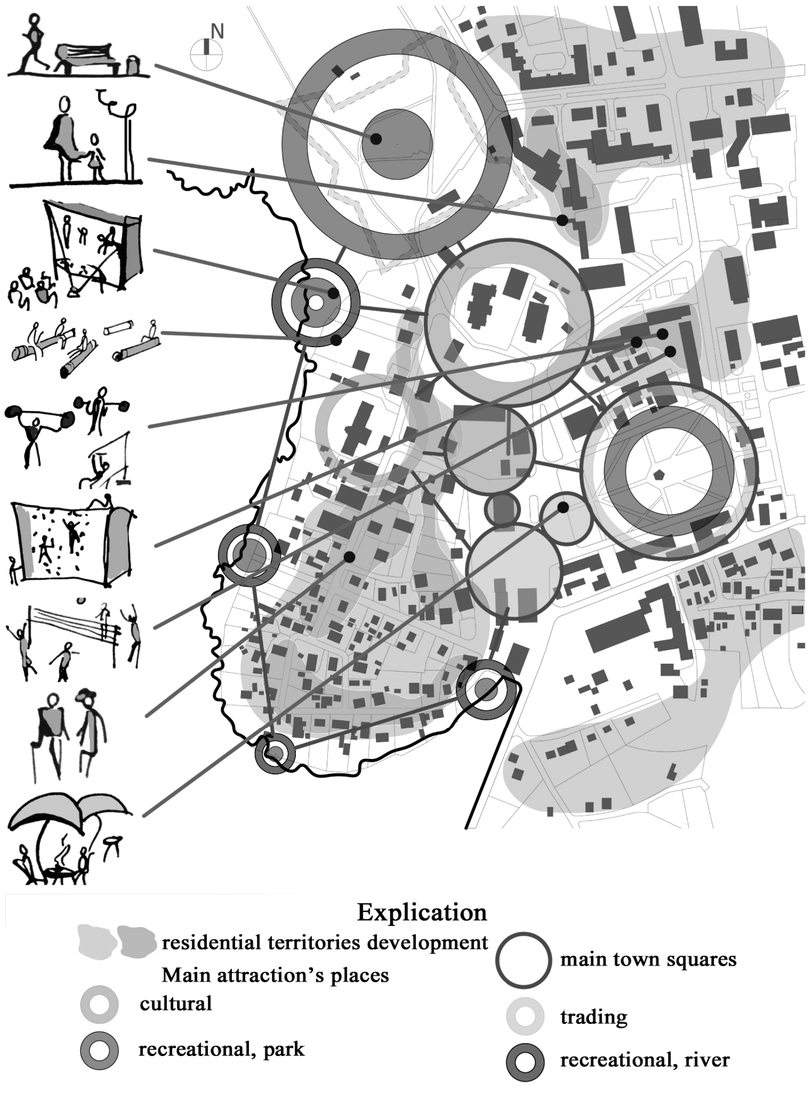

Fig. 1. The project of reconstruction of the historical center of the small town of Bar in Vinnytska region. Velichko Svetlana, 2013

The factors can be divided into three groups: forming, stable and obligatory; dynamic, changing, but having relatively long influence; dynamic, changing, but having fast influence.

Forming, stable and obligatory factors:

- geographic (geographical location; influence of climatic conditions; isolation regime; temperature conditions and character of precipitations);
- natural (the amount of local natural-appearing materials; the spirit of the place; available water resources (rivers, seas) and peculiar relief; type of planting; soil structure).

Dynamic, changing and durable factors:

- cultural (peculiarities of traditional culture, religion, art; character of traditional urban development; human-created material and spiritual values);
- historic (events; historical figures; military activity places; memorial events; place mythology, formed under the influence of historic memory; character of environment depending on people lived there);
- town-planning (architectural and spatial peculiarities; historic block size; streets location; landmarks and background development);
- social (predominant sector of employment; social status of the citizens; the age structure of a population; security situation; hospitality);
- architectural (primary urban structure; arrangement of important historical objects, landmarks; character of environment; scale; various architectural styles; stylistic peculiarities);
- national (mentality of the citizens, which influences their way of life and the character of urban development);
- religious (temples, which were built as landmarks in the center of a historic town; interaction of various faith-based communities);
- ethnic (traditions; folklore).

Dynamic, changing, but not durable factors:

- economic (operating mode; the functioning of main transport routes; modes of communication with other towns; resource endowment; well-being);
- political (town-planning politics; town symbols);
- technological (traditional material processing techniques; building opportunities; the number of experienced builders);
- technical (infrastructure of the town center);
- ecological (protection level against harmful impacts).

CONCLUSIONS

Thus, small towns' historic development under conditions of reconstruction is determined by various peculiarities, value and importance of which are analyzed in the article. All these peculiarities provide the analysis of small towns' historic environment formation and development in dynamics of its creation, character of its evolution, reasons of formations of various characteristic features for evaluating them properly in future.

1. Value of the historical town center. Generalization of importance and features of the historical town center environment.
2. Originality of small towns' historic environment. Designation of importance of town's individual character preservation.
3. Principle of historical and cultural continuity of a town. Continuity principle provides the preservation and development of the integrated environment and its identity.
4. Process of small towns' historic environment formation in the result of cultural layers in the course of time.
5. Factors, which influence the formation and development of small towns' historic environment. Analysis of the main factors, their importance depending on the level of influence on the historic town center.

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УСЛОВИЯ ФОРМИРОВАНИЯ И РАЗВИТИЯ ИСТОРИЧЕСКОЙ СРЕДЫ МАЛЫХ ГОРОДОВ

Аннотация. Проектам реконструкции исторической среды малых городов обязательно должно предшествовать изучение условий и факторов формирования и развития архитектурной городской среды исторического центра малого города. Историческая среда рассматривается как объект, компоненты которого возникли в течение исторического периода существования города, который имеет определенные закономерности эволюционного развития. Целью трансформации такой среды является сохранение своеобразия города в процессе реконструкции исторического центра. Принимая во внимание результаты проведенных поисково-аналитических работ проводится дальнейшее определение ценности этой территории. В статье проводится анализ основных ценностных характеристик формирования и развития исторической среды малых городов.

Ключевые слова: принцип преемственности, своеобразие исторической среды, временные наслоения, формирующие факторы, эволюционный процесс.

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The principles of the coastal areas in the context of large cities

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Summary. The coastal territory is the most valuable for using for urban purposes. The city and its water area has a strong influence on each other, their intersection is the coastal zone, the border between the built environment and the part of the nature.

Relevance of the study of coastal areas in big cities is being connected to their high "demand" in different historical stages. Particular planning structure of big cities is largely determined by the nature of coastal areas and natural affinity and economic conditions. Overview of urban development of coastal areas shows growing interest to them everywhere in the world. These areas are seen as the contact zone of the natural and urban landscape.

The present article considers how much the relationship between man and water area of the city was changed over the time, and what issues exist in the shaping of the coastal areas of cities nowadays.

The article provides a classification of areas of city embankments upon configuration and interaction with area waters.

The author identifies the basic principles of the coastal areas of cities, uses the integrated approach to the study of coastal areas, where they are considered as an integral part of urban space.

Key words: coastal spaces, waterfront area, coastal landscape, water front of the city.

INTRODUCTION

The history of the development of most cities is inextricably linked to water spaces within their structure, rivers, lakes or seas. Therefore, an integral part of the city with access to water areas is coastal areas. Wide expanses of water (big rivers, lakes, seas) have the greatest impact on the image of the city.

The city and its water area are in parallel artificial and natural environment, but they have a clear border crossing. Various components of the origin of the border produce specific issues which need to be addressed today's society.

The attitude to the city water area was changed very dramatically in recent years. Initially, water was considered as an obstacle to the development of the city and its connections. But with the development of science and technology people began to use the city water area and coastal areas for their own purposes.

The coastal area is valuable for using them for urban purposes.

When planning city decisions, located on the shores of large bodies of water, people tend to bring them to the downtown and residential development, create embankments which serve the city decoration, place water near large planted area. Beaches, recreation and sports water facilities are located on the banks of ponds [6].

In the current situation the deindustrialization of cities and perception of nature as an integral part of the human condition, the question the role of water space in the structure of the city, related to the importance of cross-border regions between "natural" and "artificial" is an important aspect of urban planning.

PURPOSE OF WORK

The purpose of this paper is to define the basic principles of coastal areas of big cities and show that for the time being there is need to move from individual development of coastal areas and landscapes (parks, embankments, harbors, etc.) to programming and complex concepts that take into account the basic issues of coastal areas of big cities.

MATERIALS AND METHODS

Research of coastal areas of big cities and their development should be done through a comprehensive use of the historical, cartographic, statistical and comparative analysis, allowing identifying patterns of development.

RESULTS AND DISCUSSION

The role of the embankments in the city is complex and versatile, so comprehensive solution to all issues related to its establishment and operation, is particularly important [4].

Embankments are space-planning complexes near water bodies that occupy large urban areas. They are directly connected with urban development, and water area. Embankment complex includes community facilities, natural or artificial coastal landscape, as well as underground and above-ground engineering, communications and equipment [4].

Recently, the widely used term "coastal zone" or "coastal area". They are not strict uniform concept. For the boundaries of coastal areas on the coast and the sea in different countries and in different disciplines used different principles. For example, the width of the coastal zone in different countries varies from tens of meters to hundreds of miles and difficult to detect that definition, which is most common. Also important to highlight an optimal allocation principle of the coastal territory.

According to the main trends of the coastal areas of the city we can talk about them as about areas with specific economic, social and environmental resources in the urban structure. Question of worsening of the ecological situation in the cities that deviate from the standard indicators, requires a solution. The level of air pollution, lack of green areas needs to revise the approaches to coastal areas creation, which first of all, must comply with the requirements of people.

Objective factor in building urban landscape is the size and configuration of the area.

Use sculpturesque properties of natural factors areas, conservation of landscape areas, additional planting green space can create a coherent system of green spaces and water that contributes to the formation of integrated architectural expressional urban ensembles.

In today's urban planning major role is dedicated to ensemble, not a separate building. Therefore, designing new embankments or their parts, must take into account the overall architectural and spatial ensemble of the whole embankment.

It's advisable to create accents for circuit prospects of embankments on their ends that give the completeness and architectural expression to the embankment.

It's important to take into account panoramic perception of the city extended through the water surface both the opposite bank and the water. On the banks of narrow rivers spatial development should be used for creating green margins, gaps, organizing various transversal perspectives, enriching the architectural composition of embankments.

Depending on the size of water space and its shape, location, length of embankment and its functional content itself coastal area may look like boulevard with landscape gardening or type a regular grand esplanade.

If embankments are converted into transport arteries, they must have a protective dense greenery of the residential area. These conditions should take all possible measures to ensure that this forced decision has a minimal effect on the coastal landscape, and eventually use mainly embankments for leisure of urban residents.

Improvement of embankments involves creating pedestrian alleys of areas for recreation, playgrounds, squares, parks and boulevards and improvement of road transport, landscaping and lighting, laying of underground utilities, installation of protective drainage etc.

The main role in the design of embankments is given to green spaces. Planting of greenery in embankments is performed with the maintenance of existing mature trees and shrubs in rows, individual trees or groups of free shapes so that trees do not interfere with panorama of the water reservoir, but rather emphasize the openness of perspective on the water surface.

The conditions for a short rest and walks in the green near the water have to be created, where you can enjoy the most expressive picturesque panorama of the urban landscape. While selecting green plants the height of trees and shrubs, their shape, the color of leaves and change its color at the time of flowering should be taken into consideration. The range of trees, shrubs, flowers and their composition in combination with lawns, small architectural forms can be most diverse. Lawns and flower gardens are widely used in the design of oblique embankments, creating a thick green carpet of bright spots flowers.

When planting the greenery on embankments the orientation must be taken into consideration. On the embankments, which are facing south, it is necessary to create shaded areas. In walking alleys, the greenery is usually placed on the inside of the mall.

Berths, stairs to the water, parapets, fences, rotunda and benches, decorative vases which are harmoniously inserted and artistically executed are to replenish the architecture of embankments, giving them picturesque identity. Stairs with sightseeing platforms not only connect the walking mall, laid at different levels of the slope or combine embankments with water, but are by nature of embellishment of embankments.

The picturesque embankments have a major impact in creating a unique identity of coastal cities. They are paid special attention also because they are favorite walking place for citizens and in resort cities - tourists, becoming essentially a well-ordered city recreation park.

Please note that in forming marine city's skyline the length of the coast, its outlines contribute greatly on its perception from the sea.

Concave configuration of the terrain allows perceiving dominants in expanded form with both water and land, convex - right opposite - reduces visibility. The steep hilly coast makes panorama of the city diverse and naturally divided into spatial components. Mainlines, approaching embankments, organize access to water of residential areas and architectural planning connection with residential development.

Boundary space is an integral part of the creation of waterfront zones of cities. "Boundary spaces" is a natural dominant (river, bay and sea), industrial area, office and residential buildings, transport infrastructure in all parts of the embankments [9].

"Water front" is also very important concept for coastal zones of cities. This part of city faces or borders by water: river, lake or sea. Urban areas along the banks of large bodies of water can be divided into the following functional areas:

1) on the embankments used as recreation, parks, gardens, sports facilities are created – to support favorable ecological conditions in the urban environment. Green plants are placed on the embankments considering

the overall architectural and planning decisions for territory, which depends on the functionality of the embankment, its shape and size, construction of coastal slopes and retaining walls. They are placed symmetrically on the sides of the roadway, or asymmetrically usually dominated landings, completion boulevards directly from the side of the water;

2) traffic use of the embankments is necessary to ensure access to social and functional business or industrial zones, located in the coastline;

3) residential embankments are designed to ensure communication with the waters of residential development, which favorably affects the psychological and physical health of people;

4) public embankments, which include the structure of public buildings of different destination: administrative, sports or any other buildings and structures;

5) industrial embankments which are located in large industrial areas and include in its structure factories, manufactures warehouses and other areas [14].

Classifications of embankments are also defined by their configuration and interaction with water area:

1) compact organization of embankment space is determined by the effect on water reservoir area, which surface exceeds considerably the length of the coastline and specifies a functional orientation for coastal area;

2) the linear configuration of the embankment is more common for linear cities and has a small difference of its length with an area of territory that affects its space. The coast line type has a focus and often performs a certain function;

3) batch water development is focused on cooperation of individual sections of coastline, due to territorial or functional zoning.

Depending on the horizon and boundary waters and high altitude embankments are:

1) the single-stage - these embankments are arranged at the height of the wall 5 – 5,5 m. Higher walls are inappropriate for building from architectural point of view [1];

2) two-stage and multistage embankments are build, based on engineering and economic reasons. Embankments should be provided tiered shape with vertical walls or a combination of the bevel and the wall that fortified or landscaped with stone having a slope of 1:1 – 1:1,5 [6].

A broader intermediate level offers spaces for lingering be the waterside and temporary uses such as summer cafes. This element, frequently used over longer sections of a river, is conceivable when space is limited. The divisive character of a vertical riverbank is ameliorated and the flood area is improved by broadening the cross-section [13].

A staged transition to the water over several broad terraces usually permits several users to coexist. The design emphasizes the twofold function of this area, on one hand access to the river and on the other an interesting recreational area beside the river. To develop its effect fully, this approach is suitable for longer stretches of a river. A gradual transition to the adjacent urban space can be created, without a perceptibly hard borderline. Broad riverbank steps create public space beside the water, offering direct contact with the river at various water levels. By opening new sightless they can achieve striking connections between the urban surroundings and the river. Diverse structuring of the steps enhances their various functions as movement spaces and pleasant places to linger, similar to the tiers of a sport stadium [13].

The combination of upper and lower embankments creates a wonderful game of contrasts of environments if they are allotted different functions.

However, when constructing territories, the question of economic feasibility is a key one [3].

When designing or remodeling coastal areas certain principles of zone creating, are used, helping to make architectural environment more comfortable for human beings in it.

Among the main principles of coastal zones are:

1) the principle of humanization of the space environment;

2) the principle of parity of artificial and natural components;

3) the principle bio positive spaces [15];

4) the principle of creation a single water-green frame (ecological frame of the city);

5) the principle of architectural and planning solution "approach of the city to the water" [9];

6) the principle of aesthetic harmonization;

7) the principle of the city environmental sustainability;

8) the principle of investment attractiveness [3];

9) creation of innovative urban-art image (innovative ultramodern city image) [5].

The principle of humanization of the space environment (Fig. 1) means the implementation of the principle of philosophy, which is based on respect for people, caring for them and their belief in the great potential for improvement. In general terms, it is about humanizing when the focus of all activities is given to the person and its needs [2]. During the process of humanization of the space environment, so it is meant to achieve improvement of physical, psychological and spiritual comfort for human in both artificial and natural environments [11].

The transformation of social and economic conditions leads to changes of the role and place of human in the modern world. The variety and rapid change of the needs of different social groups in organizing of their material and spatial environment are the main reasons for creating modern city-build objects for civil purpose [7]. All this determines the need to review the existing approaches of architectural and landscape creation of coastal areas of city.

Fig. 1. The principle of humanization of the space environment. Cheonggyecheon river linear park, Seoul, South Korea

Creation of equipped places for people staying at the coastal strip (pad recreation, seasonal service centers and children’s play spaces) could help reactivate the embankments landscape, implementing their unique natural resource.

The most powerful way to create a comfortable environment is a landscape improvement. Cultural development of effective landscaping of coastal areas is extremely important for big cities.

The forms of vegetation used to solve such issues: linear structure of coastal systems, creation of separate visual barriers, emphasis of ceremonial areas, scaling of environment depending on the nature of space. The transition to a consistent replacement of old with new plantings of vegetation is one of the options for coastal areas restructuring, focused on building of effective natural frame. It is appropriate to create multilevel frame with green plants (trees, shrubs, bushes) in coastal and adjacent areas.

For the perception of architectural environment as an extension of the natural using of natural materials such as natural stone and wood are needed.

This applies primarily to embankments bevels and berms surface treatment, shore strengthening constructions that are in close visual and tactile contact with people. Especially wood has great humanized possibilities [11].

Demonstrative practice of coastal areas creation in all major cities of modern world shows that natural materials are used widely everywhere.

Humanization of coastal spaces is also associated with "the concept of sustainable development» (sustainable development) [8] of cities which is actually becoming popular due to signs of crisis which can be observed in relations between human and environment. While the elements of nature are inserted in the urban landscape and when the visual and functional transformation is dedicated to increase the level of comfort this should not be limited by external order and decoration only [11].

The principle of parity of artificial and natural components (Fig. 2) consists in equal use of natural and artificial elements in the design, reconstruction and regeneration of coastal areas of big cities. Using both synthetic and natural ingredients provides the most harmonious habitat for humans.

Fig. 2. The principle of parity of artificial and natural components. Jack Evans boat harbor, Coolangatta, Brisbane, Australia

Application of means of architecture integration and landscape art (in the structure of the coastal space) is based on environmental and semiotic approach.

The principle of parity of artificial and natural components destined to ensure environmentally sustainable and identically visual field with an optimal ratio between the architectural and natural components.

The principle of bio positive space (Fig. 3) provides maximum inclusion of natural ingredients in the framework of reconstruction and new spaces designed by coastal spaces and respect for the existing natural resources. Bio positive spaces principle is the foundation and basis for enhancing the role of natural frame in refilling of coastal spaces and is the preferred choice for the natural components for the purposes of ecological renovation and new urban embankments [17].

A significant role is also given to the regeneration and renovation of postindustrial coastal areas.

Fig. 3. The principle of bio positive space. 723 E Ashby Pl, San Antonio, Texas, USA

The principle of bio positive space implies for architecture the need to improve energy efficiency of buildings and structures within the coastline and the use of alternative energy systems, economic lighting (increase of natural light due to light scattered by the internal surfaces of the building).

It is essential introduction to architectural concepts theory of "green buildings plastics» (green architecture) [12] and ecological construction.

Aesthetic harmonization principle (Fig. 4) is oriented to improve perceptions of visual quality of the coastal environment in order to achieve unity of composition of buildings, green space systems, means of visual orientation, small forms, etc.

The using of this principle allows ensuring of historic preservation and conservation of the "spirit of place" in large cities all over the world.

Fig. 4. Aesthetic harmonization principle. Ipswich River Heart City Parklands, Ipswich, Brisbane, Australia

Creation a single water-green frame (ecological frame of the city) (Fig. 5) is an integrated approach to the design of the coastal area of cities and shows that these areas are tied very closely economically and socially with the city itself.

Fig. 5. Creation a single water-green frame (ecological frame of the city). Madrid Rio Landscape, Arganzuela, Madrid, Spain

The principle of environmental sustainability (Fig. 6) is dedicated for creation of "conditions for sustainable city development, feasibility for high environmental quality of coastal areas, renovation (restoration) of water front of the city and maintaining ecological balance" [19].

Reducing of the number of potential sources of environmental stress (industry and transport) in the structure of the waterfront area is a priority direction of urban development. Reducing the anthropogenic impact on nature and human beings is directly related to the improvement of environmental coastlines quality. The modern city can't be considered humane environment in case if it doesn't use all measures to reduce the negative impact on the biosphere.

Fig. 6. The principle of environmental sustainability. Saint Martin channel, Paris, France

City planning coastal development is an integral part of environmental safety of the city [18].

Functional organization quality of the coastal areas of big cities do not fully meet the basic requirements of a modern, ecological safety, comfort space, aesthetic appeal in terms of contact of urbanized environment with the natural landscape. Due to the growth of cities – especially big ones, special attention should be given to natural complexes of coastal zones, as their reducing under the pressure of urbanization leads to the need to create methods and guidelines for the maintenance of the environment at the city planning level [10]. The creation of a single water-green city frame as a basic planning mean to ensure ecological balance of the urban environment foresees maintenance and creation of significant natural areas in the structure coastlines performing recreational, environmental and health related functions.

Architecture and planning solution of "approach of the city to the water" (Fig. 7) is an important principle of planning coastal areas of big cities. It is primarily based on transport and economic aspect of the city.

Fig. 7. Architecture and planning solution of "approach of the city to the water". East River Park, New York, USA

The principle of investment attractiveness (Fig. 8) consists in the most efficient and sustainable using of coastal resources, assuming encouragement of investments to in order to change the properties of adjacent areas to the level which will ensure their profitability. Clarification of legal aspects that make the basis for encouraging of investments at various levels can ensure the appearance of additional resources for focused and economically justified development of urban coastlines [16].

Coastal zones are the ones the most exploited and attractive investment areas due to its rich historical resources. Domestic and foreign experience of cities "near the water" can distinguish two types of coastal space: first - an industrial or commercial zone, berth for water transport; second – beach and walking park, full of comfortable seating and is a picturesque street, which hosts various cultural events. As a rule, the cities with "water front" combine both functional loading of the coastal zone, distinguishing them geographically.

With the development of coastal areas, it is important to understand that their functional saturation must meet the needs of citizens, justify costs of investors and not to destroy the environment.

Fig. 8. The principle of investment attractiveness. Nyhavn, Copenhagen, Denmark

The principle of creation of innovative urban-art image (innovative ultramodern city image) (Fig. 9) consists in creation of a water front and embankments prospective and coastal areas.

A new urban sprawl is normally developed, spatially following in a linear direction from the coast. This phenomenon is a direct effect of the improvement of transport systems, the increase of living standards and the importance of tourist activities and has led to negative effects on coastal biodiversity, a steady increase on demands for water resources and an increase of waste production and pollution.

By including coastal zone issues in the city’s development plans, an integrated approach could be generated taking into account all the essential matters for the essential matters for the achievement of effective policies for both coastal/marine and urban activities.

Fig. 9. The principle of creation of innovative urban-art image (innovative ultramodern city image). Crimean embankment, Moscow, Russia

Analysis of the cities that have their waters –rivers, lakes coast, bays, sea allows segregating of two main issues of urban landscape and coastal areas creation:

1. Functional development of embankments. Contradictions in appropriate functional applicability of coastal territory – on the one hand industrial and commercial area of the city - a place for freight and passenger water transport; at the same time the embankment is a walking zone.

There is a task to create for pedestrians' chamber and cozy environment of coastal areas: pedestrian zone, running zone, cultural zone.

Two versions of the approach and solution coastal cities can be defined – first: respect for the historical heritage of the city – the inclusion to the area of the old piers, ports and harbors, and second: it is important to use modern architectural and engineering methods of development of coastal areas, which create "collage" nature area [20].

Thus a clear segregation of promenade and industrial zones in the city should be done, besides deliberate separation of industrial flows and flows of people.

2. Integration of modern embankments in a dense urban environment. Creation of a "planning system interaction" of urban and coastal areas: architectural and spatial formation oriented to waterfront city center; including terraces and natural coast in the planning; disclosure of modern luxury development to the river or artificially created harbor, etc.

CONCLUSIONS

The coastal area of the city is one of the most attractive areas for humans; they need a complex approach in order to solve specific issues and problems that have been formed over a long period of time.

Urban areas along the coast can perform different functions - an embankment function, used for urban parks and recreational areas; waterfront function that is only used for commercial or transport purposes. The issue of zoning of coastal territories is very important according to these types of embankments for the correct and harmonious functioning of each of them.

The issue of spatial and functional correction of the urban environment is an important issue to create the coastal areas of big cities as well as environmental rehabilitation of coastal zones in big cities and ergonomic and aesthetic harmonization of architectural and landscape environment of coastal areas of big cities.

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ПРИНЦИПЫ ФОРМИРОВАНИЯ ПРИБРЕЖНЫХ ТЕРРИТОРИЙ В КОНТЕКСТЕ БОЛЬШИХ ГОРОДОВ

Аннотация. Наиболее ценными для использования в градостроительных целях являются прибрежные территории. Город и его водное пространство имеет сильное влияние друг на друга, их пересечение и является прибрежной зоной, границей между искусственной средой и частью природы.

Актуальность исследования прибрежных территорий крупных городов связана с их высокой востребованностью на разных исторических этапах. Обзор состояния градостроительного развития прибережных территорий показывает растущий интерес к ним во всем мире. Эти зоны рассматриваются как контактные зоны природного и урбанистического ландшафта.

В статье рассматривается, как с течением времени менялось отношение человека к водному пространству города и какие проблемы существуют в формировании прибрежных территорий городов.

В статье приводится классификация набережных зон города по конфигурации и площади взаимодействия с акваторией.

Автор выделяет основные принципы формирования прибрежных территорий городов, использует метод комплексного подхода к изучению прибрежных территорий, в котором они рассматриваются как неотъемлемая часть городского пространства.

Ключевые слова: береговые пространства, набережная зона, прибрежный ландшафт, водный фасад города.

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Features of base substantial differential settlements influence on structural system seismic stability

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Summary. The problem of possible combination of soil base substantial differential settlements and seismic action is characterized. This theme is extremely urgent subject to significant negative influence of soil base substantial differential settlements evolution on the construction system seismic stability. The article's aim is to consider features of such influence. The considered spectrum of the influence aspects includes: initiation of a complex stress-strain state, which loads additionally structural system when seismic loads are emerging; reduction of the structural system energy capacity to take and absorb the seismic vibration energy; abatement and rupture of seismic stability elements in the construction system; substantial change of a dynamic analytical model. The version of soil base substantial differential settlements occurrence before earthquake is selected for being studied as the most probable and destructive. Design procedure for construction systems under combination of soil base substantial differential settlements influence and seismic action on the basis of capacity spectrum method proposed by author is shortly introduced.

Key words: differential base settlements, seismic action, combination, construction system, capacity spectrum method.

INTRODUCTION

Large areas of Earth's surface are characterized by significant seismic hazard that is basically associated with a tectonic activity. Complex geotechnical natural and anthropogenic conditions which result in substantial differential settlements of base (SDSB) are widely spread too. They include slumping soils, undermined territories, karst and other suffosion kinds, creeps, new building influence, etc. Combination of such complex influences is natural and common. Thus, the protection of constructions affected by such combination is relevant.

Both earthquake and substantial differential settlements of base create significant load influence on the construction system and respective stress-strain state (SSS) with a high risk of the constructions or all system collapse. Taking into account its extreme hazard, it is logical to consider a possibility of such influences combination.

An increased complexity of research and consideration of SDSB and seismic combination results, as a rule, either in all-out removal of SDSB causes (typical of West Europe or North America) or in avoidance of problem consideration by a standardized negation of such combination possibility (typical of the post-Soviet countries).

Individual attempts of studying seismic and different SDSB kinds combination occur on the exSoviet Union territory, for example, papers [1 – 5 et al.]. Series of studies [5 – 9 et al.], which had been performed by Ukrainian Zonal Scientific and Research Design Institute of Civil Engineering (KyivZNIIEP) from 1982 to 2009 with interruptions, was the most thorough. This series was started for the purpose of developing protection methods for buildings in the slumping soils conditions of Odessa seismic region. Eventually, the range of problems had thoroughly been highlighted, the series of substantial differential base stiffness influence effects on the building seismic reaction had been revealed and the propositions for building analysis and resistance in the slumping soils conditions in seismic areas had been suggested. However, a great number of questions and problems, for example, consideration of other SDSB causes, taking into account a standardized prohibition of peculiar (abnormal) influences combination, applied engineering analysis methods development, more solid theoretical substantiation of the problem and its solutions, etc. remained unexamined. In this connection the author conducts a complex of studies to solve the above problems (some results are presented in the article).

MATERIALS AND METHODS

The article's aim is to consider SDSB features influence on the building structural system seismic stability. Methods of building literature analysis, inspection of existing buildings, modelling in bundled software, theoretical analysis, quantitative and qualitative data handling are applied in research whose results are introduced in the article.

RESULTS AND DISCUSSION

Sources analysis and the author's research have shown the following features and effects of SDSB influence on the building structural system seismic stability:

Initiation of complex SSS, which additionally loads the structural system under seismic effects.

Reduction of the structural system energy capacity and ability for taking and absorption of the seismic vibration energy.

SDSB high level involves abatement and rupture of seismic stability elements including the reduction of overloaded structure elements rigidity with efforts redistribution in the construction system.

Plastic deformations and ruptures accumulation in the construction system and probable residual changes in the soil base rigidity distribution may cause a substantial analytical model change.

Three variants of the seismic and SDSB combination are theoretically possible: SDSB occurrence before earthquake; earthquake during the active phase of SDSB; SDSB influence after structural system abatement by seismic loads. The first variant is the most probable and destructive, because earthquake probability during the active phase of SDSB (the largest duration – up to 1…2 years till complete attenuation), all the more its peak, is considerably less. And SDSB influence after earthquake applies "only" to risk of their loads on damaged buildings until their repair or dismantling completion.

Damage and rupture of building structures and elements responsible for seismic stability (main wall's sites, reinforced-concrete inclusions of walls, beams, columns, nodes, etc.) are the most apparent effects of SDSB influence. These effects initially drew attention to the problem of base deformations influence on construction system seismic stability, specifically, damages of residential and other buildings by slumping of soil base at the South-west of Odessa region in Ukraine or in countres of Central Asia, which are considired in research works [10 – 13 et al.]. Typical examples of damages in walls of masonry buildings are represented in Fig. 1.

The conclusion about causes of revealed building damages was made on the ground of analysis of cracks allocation and trajectories around sites of base slacking and availability of SDSB evolution causes. Cracks allocation in this case correlate good with generalized table of deformations variants in Fig. 2 [14].

Fig. 1. Damages of buildings bearing walls in seismic areas by substantial differential settlements of soil base

Reduction of rigidity in the construction system and, as a result, increase in natural vibrations periods and change in its mode become obvious consequences of plastic deformations and damages in bearing structures. Residual slacking of the soil base, for example, by a stable high level of subsoil water or sluggy formation may also lead to such effect. Numerical effect of the nature vibration period increase resulting from rigidity reduction of elements in the dynamic design model generally obey the well known law: $T = 2\pi\sqrt{M / K}$. That is the system natural vibration period increase is directly proportional to square root of the system overall rigidity reduction. Influence of construction system slacking goes down by soil base suppleness influence when rigidity of the base is taken into account (that is particularly important for the rigid buildings with low natural vibration period).

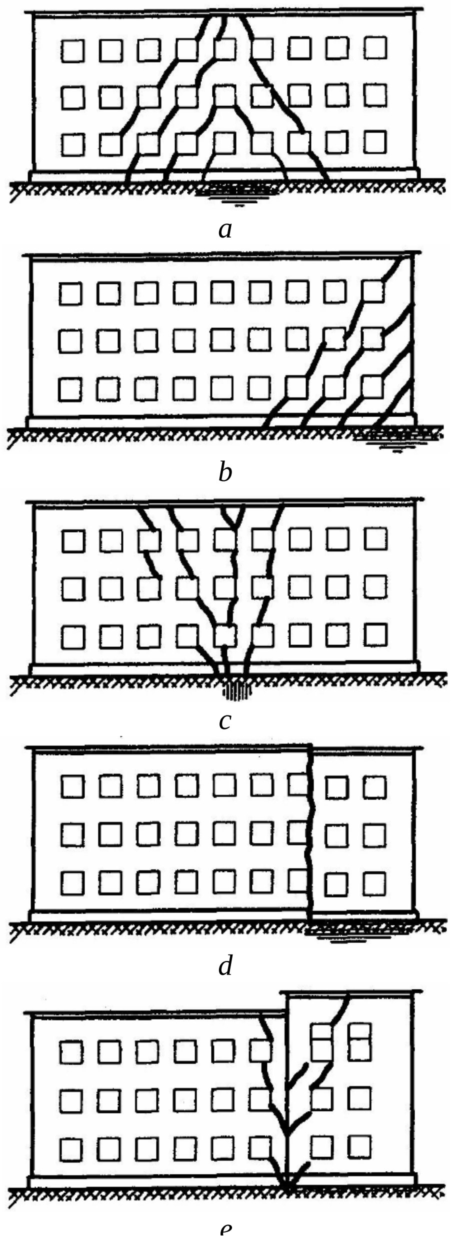

Fig. 2. Kinds of cracks allocation in masonry walls and causes of their occurrence: *a* – soil base slacking under the building midsection; *b* – soil base slacking under the shorter side of a building; *c* – hard spot in soil base under the building mid-section; *d* – stepped soil base slacking; *e* – different pressures under attached building blocks

According to the author's numerous experiments, SDSB occurrence causes reduction of general rigidity in masonry rigid building construction system up to 30% (down to 70% from starting values) due to their slacking and relevant increasing of summary periods of the natural vibration basic form up to 15% (subject to soil base rigidity). To that end nonlinear analysis was used by the principles of the capacity spectrum method (CSM) [15], specifically, generalized formulas for single degree of freedom (SDOF) systems (Fig. 3) were used for building slacked by SDSB influence.

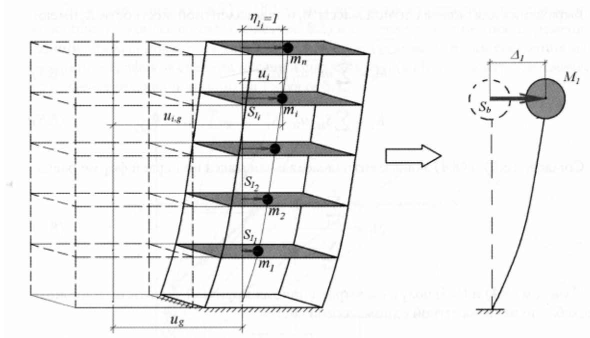

Fig. 3. Transformation of dynamic multiple degree of freedom (MDOF) system to single degree of freedom (SDOF) system

Slacking of certain masonry constructions as a result of overloads or damages by SDSB and seismic influence, in spite of a final collapse absence, reaches according to experimental data (for example, in [16]) increasing of period of the natural vibration basic form 4 times (2 times in average), and rigidity (which determines dynamic behavior and effect in general system) goes down to 10% of the initial values according to calculation data.

As regards a residual reduction of soil base rigidity after SDSB evolution completing (except sluggy formation), numerical studies indicate that a significant (more than by 10…15%) increase of periods of the natural vibration basic form occurs in low-rise rigid buildings during reduction of soil base parts rigidity down to 65% of the initial value. With an increased building flexibility and for the upper vibration forms the influence of such slacking is substantially lower or is practically absent. For detection of such regularities series of numerical experiments in software package LIRA-SAPR with models of building with up to 10 stories height (Fig. 4) were made. In the process resulting dynamic parameters were compared for the models with and without slacking of soil base.

Fig. 4. Examples of building models for studies of influence of residual reduction of soil base rigidity after SDSB evolution completing

Determination of laws of changes in rigidity and periods of buildings natural vibration in general and of their individual structures depending on damages development enables to estimate a degree of damage and slacking of various parts of the "building-soil base" system on the bases of measured dynamic characteristics, as well as to locate areas of their development.

On the grounds of features of under load materials (except perfectly brittle) deformation diagrams it is commonly known, that rigidity reduction in constructions is sign of their active or occurred before (with partial damage of material structure) overload. It can be also non-mechanical damages by a chemical or biological aggression, freezing-defreezing cycles and other occurrences [17 – 19]. These occurrences affect on constructions, as a rule, in the form of cross-section loss, inner damages and material microstructure disruption. All of that are origin of construction rigidity reduction too. Thus in-situ measurements of dynamic characteristics of construction system and their elements are universal method of technical state assessment and have gotten certain development in practice of inspection and monitoring of buildings and structures [16, 20 – 23]. It is important in this case to have base values of dynamic characteristics based on initial measurements or analysis of building with out accounting of damages and defects.

Application of dynamic characteristics monitoring also can be utterly effective for estimate of reduction of seismic stability (resistance) of structural system damaged by both earthquakes [16, 20 – 23] and other influences, including SDSB. Series of calculations has to be done for quantitative estimation of extent of structural system seismic stability reduction by SDSB, for example, with application of CSM. As a result, generalized numerical laws between increase in natural vibration periods and seismic stability reduction of different kinds structural systems will be determined for estimation of extent of structural system seismic stability reduction by SDSB.

It appears that efforts and stresses by SDSB (residual) and seismic combine with each other and bring to a substantial increase in their level in comparison with separate effect of the influences. Overall load-bearing effect by such influence on partial sites of vertical bearing elements of construction systems can be described as sidesway in two directions: vertical and horizontal. Theoretical numerical experiments show that level of efforts and stresses in this case may rise up to 2 times (by commensurability of vertical and horizontal shear forces of sidesway).

For example, a significant efforts increase in some frame constructions elements by adverse variant of combination of shear sidesway forces directions occurs. Particularly, efforts increase for shear forces and bending moments in some elements amount to 1.5…2 times. The most expected variants of construction destructions depending on its features are: by eccentric compression of columns; bending or bending with tension of beam; by shear force in beam.

For flat wall constructions adverse variant of combination of shear sidesway forces directions involves the occurrence of:

- increase of shear stresses up to 2 times;
- increase of normal stresses in the central zone approximately to 2 times;
- additional boundary normal stresses by bending action in the vertical direction.

In this case the most expected variants of construction destructions depending on its features are: by normal tension stresses in the boundary or central zones for a material with low tension strength; by normal compression stresses in the boundary or central zones (as a rule, exceed modulo of normal tension stresses); by shear stresses in the central zone.

One of the seismic analysis features is allowance of significant plastic deformations and controlled construction damages. Positive effect by plastic deformations consists in absorption of seismic vibration energy by relevant destruction of material microstructure. According to Ukrainian, Russian and other post-USSR countries building norms such effect is allowed by reduction coefficient of admissible damages for seismic forces (as a rule, $k_1 \leq 1$ [24]). Physical interpretation of this coefficient can be presented on the base of Fig. 5.

Determination of the admissible damages coefficient k_1 and other similar factors which describe the ability (capacity) of seismic vibration energy absorption for construction system under SDSB influence is a separate problem. However, on the one part, there develop plastic deformations and construction material local damages, which reduce energy capacity of the system. On the other part, due to SDSB prestressing and local damages the evolution a yield point stress (force) P_y for horizontal shear forces perception decreases. This combination generates conditions for the lack of fundamental changes of the system ductility and coefficient k_1. For example, both values P_y and P_e in the formula $k_1 = P_y/P_e$ decrease. Indirectly, this effect is confirmed by lack of the coefficient k_1 variation in the norms for equivalent type construction systems by the same level of seismic influence, though specifications of specific constructive solutions for the same type may be numerous. Thus, standard set of the admissible damages coefficients k_1 and elastic coefficients (of yielding) μ can be used for seismic analysis of construction systems under SDSB influence.

Design procedure for construction systems under combination of SDSB influence and seismic action on the basis of CSM was proposed and then improved by author. It involves following stages:

- Generation of construction system non-linear model with accounting of soil base (its rigidity or massif of finite elements). Creep of materials isn't taken into account except case of its significant influence on change of construction system design model.
- Stepwise application of static loads according to norms for seismic analysis.
- Preliminary seismic calculation of construction system without SDSB influence. Main result – diagrams of CSM and seismic spectrum in $S_a – S_d$ (ADRS) coordinates.
- Non-linear analysis on the most likely variants of SDSB influence. It is performed by special stepwise loading (by displacements or equivalent forces) or by soil base rigidity changing.
- Determination of horizontal seismic forces allocation (vibration modes) is performed by spectral method. Analysis must be done for independent orthogonal horizontal axes of building, in the line of which rigidity and stability of construction system can be considerably different. In this case stabilized rigidity of soil base (base characteristic after SDSB evolution completing can be corrected) must be used except sites with loss of contact between soil and underside of foundation. These sites have to be determined subject to creep of construction system materials (directly or indirectly). Multiplied dynamic rigidity of soil base have to be taken into account by appropriate coefficients of rigidity or by generation of soil base finite elements massif.

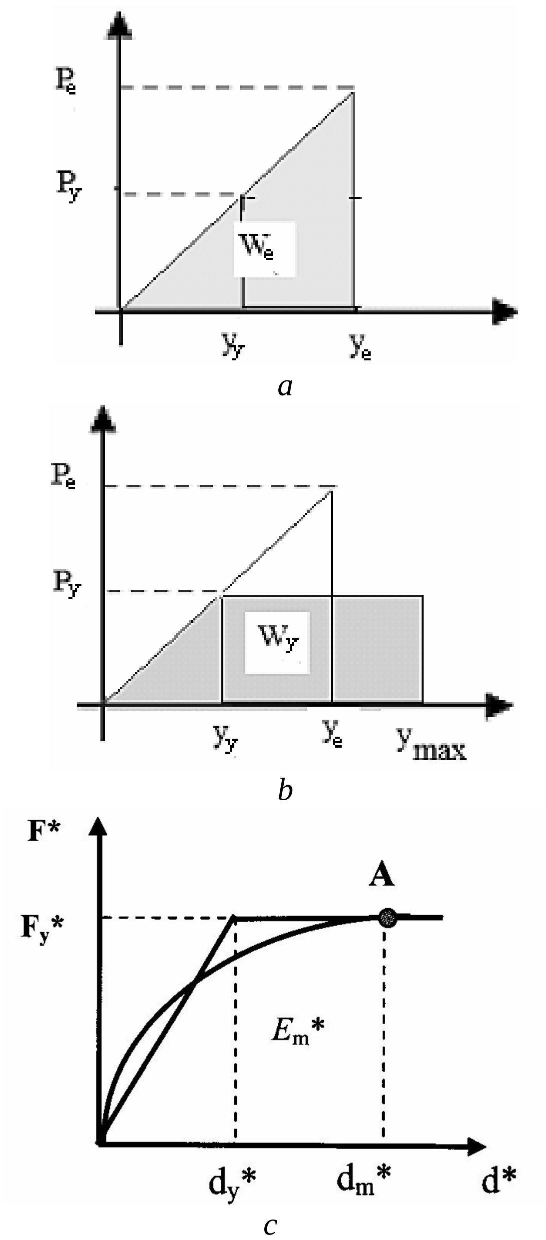

Fig. 5. Energy by: equivalent elastic (*a*) and elastic-yielding (*b*) behavior of system (W_e=W_y); CSM diagram construction (*c*). Indexes: *e* denote elastic, *y* denote yielding

- After determination of horizontal seismic forces allocation they are imposed in non-linear model after SDSB influence (SDSB postaction is allowed). Total value of seismic loads has to be assumed "with reserve" for obtaining of collapse of construction system. By stepwise application of seismic loads it is necessary to determine floor displacements with its following converting in the general equal spectral displacement S_d for SDOF with floor masses and seismic forces. Then appropriate spectral accelerations S_a is estimated. Overall result must be generated in the form of CSM diagram $S_a – S_d$.

- Plastic deformation's horizontal branch of CSM diagram $S_a – S_d$ (from limit of liquidity point a_T) can be made on the basis of experimental data. Also allowable by norms limits of elastic coefficients (of yielding) μ and limit constructive floor sidesways (without additional rotation by soil base rigidity) can be references for the horizontal branch of diagram. Before this it is important to convert CSM diagram to the bilinear form and to estimate limit of liquidity a_T.

- It is necessary to choose the most likely (to predictable building seismic stability) peak level of seismic influence spectrum according to area seismic hazard for searching of cross point of CSM and seismic influence spectrum diagrams in $S_a – S_d$ coordinates. Selected diagram of seismic influence spectrum can be corrected subject to calculable building features.

- Reduced diagram of seismic influence spectrum is made corresponding to μ. Final cross point of CSM and reduced seismic influence spectrum diagrams is generated.

- If necessary, vertical component of vibration is estimated by spectral method according to norms subject to changing of construction rigidity by SDSB influence and to capability of loss of contact between soil and underside of foundation (these sites have to be determined subject to creep of construction system materials). Simplified accounting of the vertical component by addition or subtraction of portion of vertical static loads (15% for 7 and 8 points of earthquake intensity, 30% for 9 points and no accounting for 6 points) can be used for rigid buildings by SSS analysis of their walls (or other similar braced systems). Level of seismic load vertical component is estimated by preliminary analysis of building under horizontal seismic loads. The vertical component in non-linear analysis is specified by separate loading, which is simplistically imposed before horizontal seismic or specifically stepwise in breaks of horizontal seismic. After such correction by additional loading analysis of horizontal seismic loads is carried out repeatedly and for refinements of preliminary results.

CONCLUSIONS

1. Despite a widespread disregard of the problem of possible combination of soil base substantial differential settlements and seismic action that is observed in regulations and practice, this theme is extremely urgent subject to significant negative influence of SDSB evolution on the construction system seismic stability.
2. The considered spectrum of such influence aspects includes: initiation of a complex stress-strain state, which loads additionally structural system when seismic loads are emerging; reduction of the structural system energy capacity to take and absorb the seismic vibration energy; abatement and rupture of seismic stability elements in the construction system; substantial change of a dynamic analytical model.
3. The version of SDSB occurrence before earthquake is selected for being studied as the most probable and destructive.
4. Design procedure for construction systems under combination of SDSB influence and seismic action on the basis of CSM proposed by author is shortly introduced.

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ОСОБЕННОСТИ ВОЗДЕЙСТВИЯ ЗНАЧИТЕЛЬНЫХ НЕРАВНОМЕРНЫХ ДЕФОРМАЦИЙ ОСНОВАНИЯ НА СЕЙСМОСТОЙКОСТЬ КОНСТРУКТИВНЫХ СИСТЕМ

Аннотация. Охарактеризована проблема возможного совмещения значительных неравномерных деформаций основания и сейсмических нагрузок. Данная тема является крайне актуальной по причине существенного негативного влияния, которое оказывает развитие значительных неравномерных деформаций на сейсмостойкость конструктивных систем. Целью статьи является рассмотрение особенностей такого влияния.

Рассмотренный спектр направлений воздействия значительных деформаций основания на сейсмостойкость включает: создание сложного напряженно-деформированного состояния, с дополнительным догружением конструктивной системы при сейсмическом воздействии; уменьшение энергетической емкости конструктивной системы для восприятия и поглощения энергии сейсмических колебаний; ослабление и разрушение элементов, отвечающих за разные аспекты сейсмостойкости конструктивной системы; возможность существенного изменения динамической расчетной схемы. Теоретически возможны 3 варианта совмещения воздействий неравномерных деформаций основания и сейсмики: возникновение деформаций до землетрясения, землетрясение на этапе активной фазы деформаций и действие деформаций после ослабления конструктивной системы при землетрясении. Как наиболее вероятный и опасный для рассмотрения в исследованиях выбран вариант возникновения деформаций основания до землетрясения. Коротко представлена предложенная автором методика расчета конструктивных систем на совместное действие значительных неравномерных деформаций и сейсмики на основе метода спектра несущей способности.

Ключевые слова: неравномерные деформации основания, сейсмика, совмещение, конструктивная система, спектр несущей способности.

Assessment of Transport Energy Consumption when Designing Off-Ramps of Flyunder Crossings

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Summary. Dependence between radiuses of curves of off-ramps and transport energy consumption within left- and right-turning directions of traffic of flyunder crossings with the engineering and planning solution of “cloverleaf” type with the help of software system PTV VIS-SIM is investigated. Optimum values, from the point of view of minimization of energy consumption of a transport flow, of their radiuses of curves are defined.

Key words: traffic flow, prediction model, transport energy costs, radiuses of curves, flyunder crossings.

INTRODUCTION

Street and road flyunder crossings with complete and incomplete traffic junctions depending on management of traffic and pedestrians’ motion and recommended reference speeds (V_p) at left-turning off-ramps divided into 5 classes [12]. Irrespective of junction class elements of left- and right-turning off-ramps shall be calculated and assigned on the basis of recommended V_p on off-ramps [12]. Choice of V_p within flyunder crossings in each case shall be executed on the basis of detail technical and economic calculations taking into account perspective intensity of traffic in all directions [7].

The existing assessment of planning solutions of crossings is defined by transport and road expenses. Their value, substantially, is defined by radiuses of off-ramps curves, $R = f\ (V_p)$. At the same time, an impact assessment of radiuses of curves on energy consumption of transport flow (TF) as one of the indices of operation of transport is not considered. As within different types of crossings impact of V_p on transport energy consumption is shown unequally, and on the same type of crossing energy consumption of TF changes depending on geometrical parameters of crossing and value of intensity and density of traffic of forward and turning flows, for reasonable acceptance of V_p within flyunder crossings (both on forward and turning directions) it is necessary to conduct detail research. Energy consumption of TF which values can be determined by means of special computer programs shall be one of the criteria for assessment of a choice of V_p. Indeed in the conditions of considerable foreign economic dependence of Ukraine on suppliers of energy carriers (the import share in structure of deliveries of primary types of energy carriers in different years was equal from 53 % to 72% [10] energy saving in transport branch acquires special relevance for general increase of economic efficiency of national economy.

MATERIALS AND METHODS

Optimization of radiuses of curves of off-ramps crossings with engineering and planning solution (EPS) of “cloverleaf” type from the point of view of minimization of transport energy consumption in their limits.

In the world of modern information technologies in planning and analysis of transport systems of cities, implementation of different technical and economic calculations, improving of traffic management and optimization of system of routes of public transport, etc. it is impossible to do without instrument of simulation (simulation modeling) by means of special computer programs. Their use in simulation modeling of TF dynamics considerably simplifies process of its study and control. Instruments allow us to visualize motion of each motor vehicle in the flow, to evaluate the effectiveness of decisions aimed at improving traffic management.

Recently, TF modeling in the transport network of the city is paid much attention. Thus theoretical ideas of TF dynamics develop generally in two directions. On the one hand, micromodels which describe certain specific situations of motion of motor vehicles (MV) in the areas of transport network but which at the same time can't characterize status of TF [4, 9] are considered. On the other hand, there are many macromodels for description of TF dynamics which however aren't intended for analysis of motion of MV on certain specific areas of transport network [3; 5; 8]. Today in the world there are about 30 software products for simulation the most widespread of which are AIMSUN, PARAMICS, IHSDM, Emme/4, MITSIM Transcad, VISSIM, PLANSIM-T, AUTOBAHN, TRANSIMS, DRACULA, SISTM, INTEGRATION, FLEXSYT-II, SimTraffic 6 [1, 6, 17].

In the articles of A.V. Kochetkov, M.M. Bekmahambetov, A.V. Yatskiv, E.A. Yurshchevich., N.V. Kolmakova [1, 19] it is given a comparative assessment of the most widespread software products for simulation modeling on the major criteria for the analysis of transport situations. If to enter indexes for simulation objects and phenomena: weather conditions (1); inspection for parking spaces (2); parked cars (3); specification of engines models (4); commercial cars (5); bicycles and motorcycles (6); pedestrians (7); road traffic accidents (8); public transport (9); measures for stabilizing of flows (10); diffusions of bunching (11); weaving of flows (12); out-of-straight (13), possibilities of software as for their accounting will be marked in the Tab. 1 with symbol X. If to enter the indicators designating the whole simulations according to Tab. 2, possibilities of software as for the accounting of these purposes will be provided similarly in Tab. 3.

As a result, due to ease of use, polyfunctionality, high adaptability, ability to build the most detailed models which are closest to real for further research it is chosen the German model of software family PTV VISION which combines full software package for planning, analysis and traffic management [14].

Table 1. Possibility of objects and phenomena description

Software	1	2	3	4	5	6	7	8	9	10	11	12	13
AIMSUN2	-	-	-	-	-	-	-	*X*	*X*	-	*X*	*X*	*X*
CORSIM	-	*X*	*X*	-	*X*	-	*X*	*X*	*X*	-	*X*	*X*	*X*
DRACULA	*X*	-	-	-	*X*	-	-	*X*	*X*	-	*X*	*X*	*X*
FLEXSYT-II	-	-	-	-	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*
PARAMICS	*X*	*X*	-	-	*X*	-	-	*X*	*X*	*X*	*X*	*X*	*X*
SYSTEM	*X*	-	-	-	*X*	-	-	*X*	-	-	*X*	*X*	-
VISSIM	-	-	*X*	*X*	*X*	-	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Table 2. Simulation purposes

Purpose	Indicator	Purpose	Indicator
Efficiency	*E*1: modal division	Safety	*S*1: headways
	*E*2: motion time		*S*2: overtaking
	*E*3: motion time changes		*S*3: time of the incident
	*E*4: speed		*S*4: number of accidents
	*E*5: bunching		*S*5: speed / incident consequence
	*E*6: frequency of public transport		*S*6: interaction with pedestrians
	*E*7: queue length	Convenience	*F*1: bodily comfort
Environment	*V*1: emissions release		*F*2: stress
	*V*2: level in case of trunk pollution	Technical features	*T*1: fuel consumption
	*V*3 noise level:		*T*2: operation costs

Table 3. Target capability of models

Software	*E*1	*E*2	*E*3	*E*4	*E*5	*E*6	*E*7	*V*1	*V*2	*V*3	*S*1	*S*2	*S*3	*S*4	*S*5	*S*6	*F*1	*F*2	*T*1	*T*2
AIMSUN2	*X*	*X*	-	*X*	-	-	*X*	*X*	-	-	-	-	-	-	-	-	-	-	*X*	-
CORSIM	-	*X*	*X*	*X*	*X*	-	*X*	*X*	-	-	-	*X*	-	-	-	-	-	-	*X*	-
DRACULA	-	*X*	*X*	-	-	-	-	*X*	-	-	-	-	-	-	-	-	-	-	*X*	-
FLEXSYT-II	-	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	-	*X*	-	-	-	-	*X*	-	-	*X*	-
PARAMICS	-	*X*	*X*	*X*	*X*	*X*	*X*	*X*	-	*X*	*X*	*X*	-	-	-	-	-	-	*X*	-
SYSTEM	-	*X*	*X*	*X*	*X*	-	*X*	-	-	-	*X*	*X*	-	-	-	-	-	-	-	-
VISSIM	*X*	*X*	*X*	*X*	*X*	*X*	*X*	*X*	-	-	*X*	*X*	*X*	-	-	*X*	-	-	*X*	-

Principal components of PTV VISION system are VISEVA module, VISUM and VISSIM models [20]. VISSIM model which allows to model TF motion as on micro- (within separate crossings), and macro- (on the scale of all city) level due to implementation of traffic simulation model is applied to support the solution of the tasks planned by us on optimization of EPS choice of flyunder crossing from the point of view of minimization of expenditure of fuel and energy resources (FER).

Prediction model is constructed on the basis of time intervals, microscopic model in which unit “driver MV” is considered as the smallest unit.

For determination of energy consumption of TF within the projected versions of planning solutions of crossings in the program system PTV Vissim TF motion in their limits is modelled. Thus road conditions which, on the one hand, create TF status, and on the other hand shall conform to requirements of TF for support of the transport utilization properties are considered [11].

TF prediction model considers psychophysiological model of passing after “vehicle ahead” according to Wiedemann by means of implementation of parameters, based on stochastic allocation of TF and considers motion of all MV types: motor-cars, trucks and passenger cars. Allocation of their intensities is established by means of percentage allocation of each type of MV in the general TF. Thus further class division for trucks depending on their loading capacity, for buses – capacity, and for cars – engine displacement is accepted according to standard North American fleet of motor vehicles.

Vissim prediction model enables simulation of TF motion in the most common operation modes of automobile engines in the conditions of city traffic: idling and partial loads [2]. Depending on MV type nature of their motion within the given area of a way will differ. Indeed for each type of MV in Vissim in case of different specific transport situations nature of change of acceleration and braking will be different. In all cases acceleration or braking is a function of actual speed.

One of the factors of transport energy consumption formation is MV loading capacity. As the loading capacity of motor and passenger MV is largely determined by the number of passengers, in case of TF energy consumption assessment within crossings of city trunks (CCT) it is necessary to consider their fullness. Indeed transport energy consumption of the same MV under the same initial conditions, depending on its fullness, will differ. Vissim prediction model allows us to establish average filling coefficient of motor and passenger MV. According to the opinion poll conducted for development of transport model by Kyiv International Institute of Sociology from December, 2014 till March, 2015, by the specialists of JSC “A+C Ukraine” it was found that average filling coefficient of motor-cars for the city of Kyiv is 1,51 which will be accepted for further research. According to own on-site investigations filling coefficient of buses is accepted as 25,0. Thus within prediction model there are no stops of public transport.

Formation of transport energy consumption of trucks doesn't consider their fullness, but it is defined by ratio capacity / weight. In metric units minimum is 7 kW/ton, and maximum is 30kW/ton. Weight of trucks is defined with the help of mass distribution. For each truck Vissim in a random manner selects the appropriate value from the assigned mass distribution and power distribution [18].

Functions offered in Vissim for motor-cars for maximum acceleration approximately correspond to functions in MV model Wiedemann 74. For motor-cars results of the measurements taken before 1974 in Germany were a little optimized due to the restriction set by the user in the field of short temporal steps (Minimum – Maximum). Data for acceleration away were compared to the results of MV testings, received in 2004 within the European research project RoTraNoMo. For trucks curves for acceleration and braking were optimized taking into account data of the European research project CHAUFFEUR 2, 1999. For buses curves correspond to the data provided by transport enterprise of the city of Karlsruhe, 1995. At the same time rated value of acceleration (irrespective of MV type) is optimized depending on value of a gradient on the given area [18]:

- on 0,1 m/sq.s on a gradient percent with a sign “+”;
- on –0,1 m/sq.s on a gradient percent with a sign “–”.

Frequency distribution function of intended speeds within CCT is especially important parameter influencing throughput of crossing and transport energy consumption in its limits. As intended speed the reference speed regulated by norms (depending on the category of trunk and class of junction) is accepted. Frequency distribution of intended speeds is defined irrespective of MV type.

Entering TFs in prediction model are distributed by the principle of distribution of Poisson. Thus transport energy consumption within all elementary areas of crossings (right- left-turning, swing and forward directions) needs to be calculated separately, changing, thus, priority of passage of a conflict zone (textures and branch rouds) for forward and turning TF. Indeed nature of change of TF energy consumption for each of the given intersection elements the different. At the same time calculation is performed for TF of different intensity, indeed energy consumption of a single MV on a certain area will differ from energy consumption by the same MV as a part of TF in case of a certain mode of motion on the same area. Thus research is carried out in strictly fixed limits of crossing on a dry asphalt concrete covering.

Within turning traffic directions on CCT there are areas of a way (zone of low-speed traffic) where MV driving speed will be lower, than the set reference speed. Within these areas corresponding speed which is valid for this area of a way is set. Herewith MVs, already before the zone of low-speed traffic, automatically reduce the speed and drive with the lower speed in this zone. After its overcoming MVs recover the set reference speed and automatically accelerate.

Calculation of expenditures of FER for any TF is performed by means of standard formulas for values of MV expenditure with TRANSYT 7-CB, program for optimization of temporal signals, as well as data on the value of emission OakRidge National Laboratory US Department of Energy.

RESULTS

Analysis of influence of radiuses of curves of off-ramps on transport energy consumption was checked on flyunder crossings with engineering and planning solution "cloverleaf" type. They should be used on junctions of classes *II*, *III* and *IV* with intensity of left-turning TF less than 15% [12]. In this regard, according to the Tab. 3.3 [12], V_p at left-turning off-ramps is accepted within 15...60 km/h., and on forward directions (according to Tab. 7.1 [13] – 60...80 km/h. Thus, according to the category of trunk, on forward directions it is accepted from 4 to 8 lanes in both directions [13].

On the basis of earlier developed classification of flyunder crossings depending on TF composition, location and assignments [15] data on number of crossings with EPS of "cloverleaf" type in the city of Kyiv for different groups of crossings are given (Tab. 4).

For each of the given groups of crossings full-scale survey are conducted to determine the parameters of TF within its limits. Because combined groups of crossings have similar, to some major groups of crossings, structure of TF, for implementation of further research we will integrate them:

- On the approaches to the city – with railway lines → on approaches to the city;
- In the central zone of the city – with railway lines → in the central zone of the city
- Bridge-crossings – with railway lines → bridge-crossings.

So, typical for specific group of crossings structure of TF is given in Tab. 5.

In case of identical characteristics of entrance TF the change of percentage distribution of TF by the directions causes the change of index of transport energy consumption within crossing. However in this research for all prediction cases we accept the following percentage distribution of TF:

- 67% – forward TF;
- 15%: – left- and right-turning TFs;
- 3% – swing TF.

Radius of curvature and gradient are set as key parameters of impact on TF energy consumption on the turning directions. Thus the speed of the curvilinear motion of a car is accepted as constant throughout the whole turn. When reviewing all path of motion of

Table 4. Distribution of crossings with EPS of "cloverleaf" type on groups

Group of crossings	Number, pcs.
On the approaches to the city	5
with railway lines	2
In the central zone of the city	3
Bridge-crossings	1
Other crossings	7
Integrated	
On the approaches to the city – with railway lines	1
In the central zone of the city – with railway lines	3
Bridge-crossings – with railway lines	2
Total	24

Table 5. Structure of TF

Group of crossings	Intensity, %		
	Motor-cars	Trucks	Passenger vehicle
On the approaches to the city	73,2	23,0	3,8
With railway lines	78,6	9,3	12,1
In the central zone of the city	84,0	3,0	13,0
Bridge-crossings	75,0	15,8	9,2
Other crossings	77,0	12,4	10,6

MV on the given direction it is necessary to consider transport energy consumption both on entry point, and pulling-out from off-ramps. At the same time change of a gradient on the turning directions in case of adjustment of radiuses of off-ramps wasn't considered.

During the research of flyunder crossings with EPS of “cloverleaf” type it was defined transport energy consumption within crossings depending on radiuses of left-turning off-ramps ($R = f(V_p)$). Radiuses of horizontal curves (R), depending on the accepted V_p at off-ramps, are accepted in compliance with Tab. 6 [12].

Calculation is performed for right- and left-turning TF in case of different prediction intensities within crossings, indeed the mode of motion is one of the factors influencing transport energy consumption [16]. Research is carried out for cases, when summary intensity of TF ($N_{sum.}$) within crossing exceeds 6000cars/hour that conforms to normative requirements necessarily for arrangement of flyunder crossings [12] and doesn't exceed maximum intensity of TF (11000 cars/hour) that leads to formation of bunchings and long stops in case of the given structure of TF. In this regard some variants of crossings with EPS of “cloverleaf” type with V_p on turning and forward directions which conform to requirements of State Construction Standards B.2.3-5-2001 are designed and analysed for this purpose.

Table 6. Radiuses of curves

V_p, km/h	R, m
15	15
20	15
30	35
40	65
50	110
60	160

Nature of change of transport energy consumption for the left-turning motion directions when $N_{sum.}$ = 6000 cars/hour, intensities of incoming flow ($N_{inc.}$) 1500 cars/hour and variable structure of TF, V_p = 60 km/h and 4 lanes in a forward direction (by provision of priority of motion to forward TF), is provided on Fig. 1.

Nature of change of transport energy consumption for the left-turning motion directions when $N_{sum.}$= 11000 cars/hour, $N_{inc.}$= 4000 cars/hour and variable structure of TF, V_p = 60 km/h and 4 lanes in a forward direction (by provision of priority of motion to forward TF), is provided on Fig. 2.

At right-turning off-ramps, proceeding from conditions of motion safety, V_p shan't exceed 60 km/h and should be most approached to the speed on forward directions [12]. In this regard transport energy consumption on the right-turning motion directions in case of different radiuses of border crossings and branch roads of right-turning off-ramps which correspond to the range of reference speeds within 30...60 km/h and steady radius of left-turning off-ramps was defined (R = 35 m). Nature of change of transport energy consumption for the right-turning motion directions when $N_{sum.}$= 6000 cars/hour, $N_{inc.}$= 1500cars/hour and variable structure of TF, V_p = 60km/h and 4 lanes in a

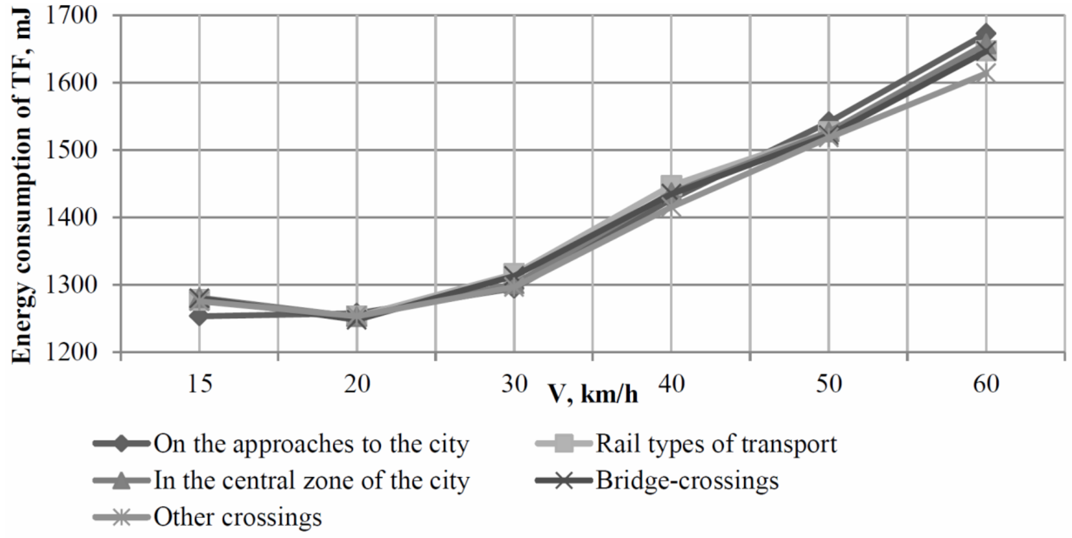

Fig. 1. Nature of change of TF energy consumption in the left-turning direction when $N_{sum.}$ = 6000 cars/hour

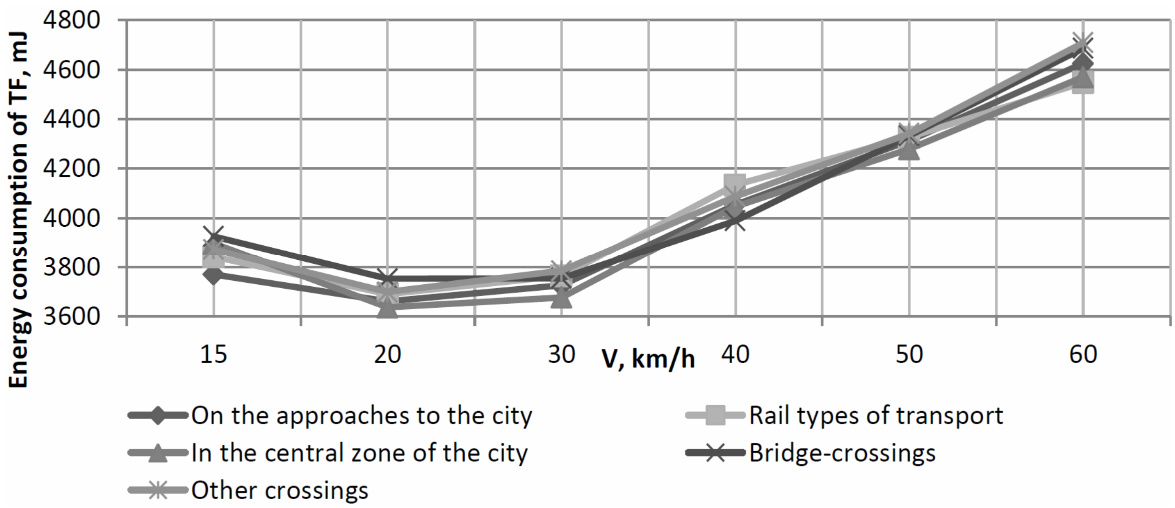

Fig. 2. Nature of change of TF energy consumption in the left-turning direction when N_{sum} = 11000 cars/hour

forward direction (by provision of priority of motion to forward TF), is provided on Fig. 3.

At right-turning off-ramps, proceeding from conditions of motion safety, V_p shan't exceed 60 km/h and should be most approached to the speed on forward directions [12]. In this regard transport energy consumption on the right-turning motion directions in case of different radiuses of border crossings and branch roads of right-turning off-ramps which correspond to the range of reference speeds within 30...60 km/h and steady radius of left-turning off-ramps was defined (R = 35 m).

Nature of change of transport energy consumption for the right-turning motion directions when $N_{sum.}$ = 6000 cars/hour, $N_{inc.}$ = 1500cars/hour and variable structure of TF, V_p = 60 km/h and 4 lanes in a forward direction (by provision of priority of motion to forward TF), is provided on Fig. 4.

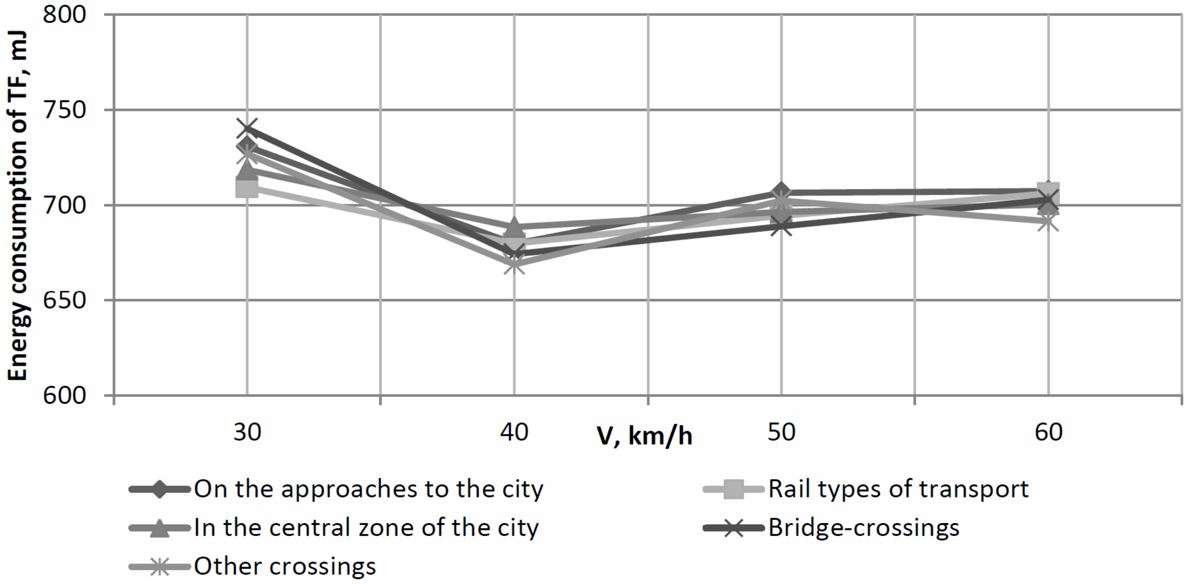

Fig. 3. Nature of change of TF energy consumption in the right-turning direction when $N_{sum.}$ = 6000 cars/hour

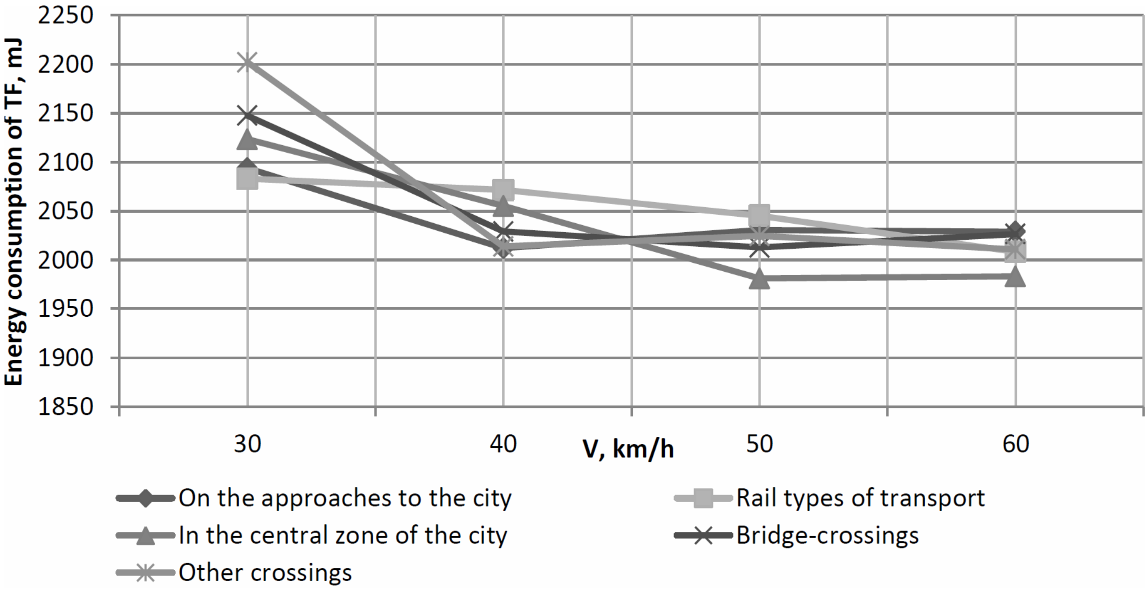

Fig. 4. Nature of change of TF energy consumption in the right-turning direction when $N_{sum.}$ = 11000 cars/hour

CONCLUSIONS

In the analysis of results of TF energy consumption research under the given minimum ($N_{sum.}$ = 6000 cars/hour), maximum ($N_{sum.}$ = 11000 cars/hour), as well as intermediate ($N_{sum.}$ = 7000 cars/hour, $N_{sum.}$ = 8000cars/hour, $N_{sum.}$ = 9000 cars/hour, and $N_{sum.}$ = 10000 cars/hour) intensities of TF it is established that TF energy consumption of the turning directions is influenced by radiuses of curves of off-ramps. It is established that the smallest transport energy consumption (for all groups of crossings) arises under radiuses of left-turning off-ramps 15m and V_p = 20 km/h. Thus the structure of TF doesn't influence nature of distribution of TF energy consumption. At the same time, with growth of $N_{sum.}$ the range of change of indices of TF energy consumption grows both in the left-turning, and in the right-turning directions. Within right-turning off-ramps (with growth of $N_{sum.}$) directly proportional linear dependence of TF energy consumption reducing from increasing in radiuses of curves of right-turning off-ramps is seen, that is the characteristic for all groups of crossings. As a result, optimum (on the index of transport energy consumption) the radius of right-turning crossings, depending on $N_{sum.}$, ranges within 65...160 m and doesn't depend on structure of TF.

One of selection criteria of the engineering and planning solution of flyunder crossing are technical and economic indices (transport, road, given expenses, etc.). However, today, among the existing evaluation indices there is no transport energy consumption. On the basis of the conducted research it is established that TF energy consumption in the left- and right-turning directions is defined by radiuses of curves of off-ramps and by the extent of TF. As far as specified parameters, except for transport energy consumption, influence the other technical and economic indices, for an objective assessment of the planning solution of crossing by the separate evaluation criterion should appear TF energy consumption.

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ОЦЕНКА ТРАНСПОРТНЫХ ЭНЕРГОЗАТРАТ ПРИ ПРОЕКТИРОВАНИИ СЪЕЗДОВ ПЕРЕСЕЧЕНИЙ В РАЗНЫХ УРОВНЯХ

Аннотация. Исследована зависимость между радиусами кривых съездов и транспортными энергозатратами в пределах лево- и правоповоротных направлений движения пересечений в разных уровнях с инженерно-планировочным решением типа «клеверный лист» с помощью программного комплекса PTV VISSIM. Определены оптимальные, с точки зрения минимизации энергозатрат транспортного потока, показатели их радиусов кривых.

Ключевые слова: транспортный поток, расчетная модель, транспортные энергозатраты, радиусы кривых, пересечения в разных уровнях.

The effect of cracks on the bearing capacity of masonry structures

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Summary. The research of the effect of different types of cracks in the elements on their bearing capacity according to the calculations by past and current codes – Building Regulations II-22-81 (SNiP II-22-81) and State Building Codes of Ukraine V.2.6-162:2010 (DBN V.2.6-162:2010) respectively, has been conducted. The effect of the three types of cracks in the masonry structures – through vertical (single, not the compressive overload ones), through horizontal and inclined ones along indents on the bearing capacity of masonry has been analyzed. The paper provides the numerical example in which the bearing capacity of the masonry pier in the initial state (before cracking) and after cracking has been analyzed according to the calculations by the above codes.

Key words: masonry structures, cracks, bearing capacity, central and eccentric compression, principal tensile stresses.

INTRODUCTION

Throughout Ukraine a large number of masonry buildings is erected and actively used. During the operation buildings receive different types of damages caused by numerous factors. The features of the negative effects on building structures and conditions of their non-destruction are specified in [1 – 3]. A more generalized research of the effects of typical defects and damages of masonry structures and buildings on their bearing capacity, conducted by the author, is described in [4].

In the publication [5] the author determined that one of the specific types of damages of masonry that affect the bearing capacity the most are cracks in the body and joints of structures. The research of the results of the inspection of a large number of buildings in Ukraine [6 – 10] has shown that a very substantial part of masonry buildings are subject to the occurrence of through vertical, inclined and horizontal cracks. The presence of these cracks in the structures undoubtedly negatively affects their bearing capacity and rigidity. This subject requires a research because it is necessary to assess the degree of reduction of the bearing capacity of the structure with cracks for a particular type of load. In the previous studies of this subject ([11 – 13]) the consideration of cracks when assessing the bearing capacity and seismic resistance of masonry structures is fragmented and (or) indirect (either too isolated or too general cases and indicators are considered) with the lack of clear systematization of their effects.

MATERIALS AND METHODS

The aim of the study the results of which are outlined in this paper is to determine, generalize and systematize the effects of cracks in the masonry structures on their bearing capacity.

The main method of the study is the analysis of the effect of cracking on the components of the formulas of the check of the masonry bearing capacity.

GENERAL PROVISIONS

The most crucial checks of the bearing capacity of masonry structures according to SNiP II-22-81 [14] are the checks of:

1) the eccentric compression;
2) the shear;
3) the principal tensile stresses.

As to the calculation by the current standards of Ukraine DBN V.2.6-162:2010 [15] adapted to Eurocode 6 [16] the essence of the eccentric compression and shear checks according to them remains. The main difference in the bearing capacity check between the past and current standards is that DBN V.2.6-162:2010 [15] has no analogues of the calculation of the principal tensile stresses for the unreinforced masonry. Instead DBN contains calculations for the bending check of the masonry.

Let us analyze the effect of the three types of cracks in the masonry structures – through vertical (single – not the compressive overload cracks), through horizontal and inclined ones along indents according to the above bearing capacity checks on the example of their formation in a pier.

THE EFFECTS OF CRACKS ON THE BEARING CAPACITY OF MASONRY STRUCTURES ACCORDING TO THE CALCULATIONS BY SNiP II-22-81

Single vertical through cracks (not the compressive overload ones). When a crack of this type appears, a solid section is divided into two separate parts. Therefore, when checking the bearing capacity of the element for the central and eccentric compression its separate sections are use instead of the solid one. The following formula is given for the calculation of the eccentrically compressed elements according to SNiP [14] (hereinafter all symbols are in accordance with [14]):

$$N \le m_g \varphi_1 R A_c \omega. \qquad (1)$$

With the reduced cross-sectional area of the element the value of all the factors of the formula (1) will decrease, except for R (but it can also be reduced according to p. 3.11, *a* [14]). Thus, when the parts of the solid section are separated, the flexibility of the element λ and λ_c increases. This entails the reduction of values of the buckling factors φ and φ_c, and thus φ_1, which is the half of their sum.

The reduction of the compressed area A_c is evident at the reduced section.

The formula for determining the m_g factor contains the cross-sectional height h, which will be lower at the reduced thickness of the element, and the з factor, the value of which increases with the increase of the flexibility of the element λ.

However, the formula (1) contains a factor, the value of which increases with the decrease of the cross-sectional height h – ω factor, which takes into account the cage effect and is determined as $1+e_0/h$.

The following formula is given for the calculation of masonry for shear in the horizontal untied joints and the tied joints for the rubble masonry according to SNiP [14]:

$$Q \le (R_{sq} + 0{,}8 n \mu \sigma_0) A. \qquad (2)$$

Similarly to previous check the design cross-sectional area A and its compressed part A_c (with decreasing of the cross-sectional height) will reduce (however the proportion of the shear force on the isolated area will reduce as well), but the value of the average stress from the compressive force σ_0 will slightly increase. A significant reduction in the total bearing capacity of the general pier from two separate parts is not expected.

The following formula is provided for the calculation of the elements for the principal tensile stresses according to SNiP [14]:

$$Q \le \frac{R_{tq} A_c}{\nu} \tag{3}$$

The formula of determining R_{tq} contains the multiplier σ_0 – the average stress of the compressive force, the influence of which is similar to the shear verification of the masonry, so at the decrease of the design cross-sectional area A_c we obtain a slight increase in the value of the design resistance R_{tq}, that is offset by an expected decrease in the size of the value of A_c itself (with decreasing of the cross-sectional height).

Horizontal through cracks. With the presence of this type of cracks when verifying the masonry of the eccentric compression there are certain features for the determination of the ω factor, which takes into account the cage effect. In this case the part of the section A_c in the limit state works with the same stresses equal to the local compression (crushing) strength limit R_c [17, 18]. For the masonry of small stones outside the ratio between the breaking points of the crushing and the compression is:

$$\frac{R_c}{R} = \sqrt[3]{\frac{A}{A_c}} \tag{4}$$

It follows from the above and further transformations that in this case the ω ratio can be determined by the formula:

$$\omega = \sqrt[3]{\frac{A}{A_c}} \tag{5}$$

When checking the masonry for shear according to the formula (2) the value of its respective design resistance R_{sq} in the section with a horizontal crack will be equal to zero due to the lack of adhesion between the parts that are shifted relative to each other. Only the second member of the formula (2) which is responsible for the friction forces will be involved in the check.

When checking the masonry for the principal tensile stresses its cleavage along the inclined indent is analyzed. When the cleavage of the masonry with a horizontal crack occurs, in the place with a crack along which the cleavage indent passes there is no contact between chipping parts. Therefore, when this check of the masonry is performed, it is advisable to exclude the area with the width of a brick size on which the cleavage indent coincides with the crack from the design area A_c. The maximum value of the width of the excluded area corresponds to the maximum size of a brick of 250 mm.

Cracks along inclined indents. In the case when the masonry with this type of crack is subject to the eccentric compression on the area of the design section of the masonry where a part (step) of the indent passes, there is no adhesion and normal contact between the parts of the element separated by a crack. Therefore, when calculating the masonry for the eccentric compression it is necessary to use the weakened cross-sectional area A_c with the reduction of the design resistance by 25% in the area with the width of a brick size where the crack indent passes along the design section (up to 250 mm).

The determination of the ω factor in the situation of the inclined crack does not change and is conducted according to the provisions of [14].

When the masonry element with an inclined crack is subject to the shear there is a similar effect as for the eccentric compression. In this case the design area A_c should be weakened by excluding the area of the design section of a brick size (of the width up to 250 mm) in which there is no contact between the parts of the element.

When the principal tensile stresses act in the masonry with an inclined crack its cleavage resistance R_{tq} is equal to zero since the resistance in the indent of both components R_{tw} (tensile and shear at tension) is equal to zero:

$$R_{tq} = \sqrt{R_{tw}(R_{tw} + \sigma_0)} = 0 \text{ при } R_{tw} = 0. \quad (6)$$

However, if a vertical compressive stress is detected in the respective area along the indent (for example, when calculating in the software), the shear resistance will not be equal to zero at the action of friction forces and it can be estimated by the formula (2).

THE EFFECTS OF CRACKS ON THE BEARING CAPACITY OF MASONRY STRUCTURES ACCORDING TO THE CALCULATIONS BY DBN V.2.6-162:2010

Concerning the checks of the bearing capacity according to DBN V.2.6-162:2010 [15], the calculations and the effects of cracks are quite similar to those performed according to SNiP II-22-81 [14], except for the absence of the consideration of the principal tensile stresses and the existence of the bending check. The absence of the first check in the current standards is a disadvantage because under certain specific effects (including seismic ones) the destruction often takes place at the principal tensile stresses (cross inclined cracks). However, the conventional analogue in DBN is the bending check of the masonry (p. 11.3.1 [15]). Let's estimate the effect on the results according to the calculation by DBN V.2.6-162:2010 of the presence of 3 types of cracks considered above.

Vertical through cracks. This effect is taken into account in a similar way as according to SNiP [14]. The following formulas are provided for the calculation of elements under the vertical, shear and bending loads respectively according to DBN [15] (hereinafter all symbols are in accordance with [15]):

$$N_{Ed} \leq \Phi\ t\ f_d. \quad (7)$$

$$V_{Rd} \leq f_{vd}\ t\ l_c. \quad (8)$$

$$M_{Ed} \leq f_{xd}\ Z. \quad (9)$$

Similarly to SNiP [14] if there is a vertical crack, the calculation of the separate sections is performed as well, and in the result the values of the respective factors in the formulas (7), (8) and (9), such as the flexibility and eccentricity factor Φ, the length of the compressed part of the wall l_c and the resistance moment Z experience significant losses.

Horizontal through cracks. When performing the calculations according to DBN [15] the horizontal crack is taken into account in the checks for central, eccentric compression and shear in the similar way as for SNiP [14]. In the bending check by the formula (9) the bending strength of the masonry f_{xd1} will be equal to zero since there are no connections between the separated parts, therefore only the component of the bending resistance from the compressive stresses remains and this formula will have the following form:

$$M_{Rd} = \sigma_d Z. \quad (10)$$

Cracks along inclined indents. An inclined crack is taken into account in the central and eccentric compression checks in the similar way as for SNiP [14]. If the element experiences the shear load, then the resistance to the horizontal force on the area of a brick size along which the crack indent passes must be equal to zero. However, if there are compressive stresses on the horizontal areas of the indent, the residual strength of the horizontal force is present because of the friction forces in these areas. In the case of a bending load the bending resistance in the horizontal section will not reduce significantly.

The assessment of the effect of cracking in the material of structures on the reduction of the power consumption and plasticity of a structural system with a possible corresponding increase of the damage tolerance factor k_1 according to DBN [19] requires a separate consideration and research.

AN EXAMPLE OF DETERMINING THE EFFECT OF CRACKS ON THE BEARING CAPACITY OF THE MASONRY PIER

To understand the effect of cracks on the bearing capacity of the element we analyze the bearing capacity of a brick pier with thesizes of 0,51×0,77×2,8 m before and after the formation of cracks of the foregoing types. The pier is built of bricks with the sizes of 0,25×0,12×0,065 m. The calculation for the effect of vertical and horizontal forces was performed according to the past codes SNiP II-22-81 [14] and the current ones DBN V.2.6-162:2010 [15]. The cases of the central (e = 0) and eccentric (e = 0,17h = 0,131 m – the eccentricity is on the border of the cross-sectional core) application of the vertical compressive force are considered. Vertical, horizontal and inclined cracks were taken into account according to the foregoing principles. The dimensions of the separated sections for the calculation with consideration of vertical cracks are taken as 0,51×0,46 m and 0,51×0,31 m.

The results of the calculation are presented in Tabs. 1, 2 and graphically in Figs. 1, 2. The following designations are used in this tables: N_u, N_{Rd} – the initial bearing capacity of the pier for the vertical force; N_{u1}, N_{Rd1} – the bearing capacity for the pier with a crack of the vertical force; Q_u, V_{Rd} – the initial bearing capacity of the pier for the horizontal force; Q_{u1}, V_{Rd1} – the bearing capacity of the pier with a crack for the horizontal force; $k_N = N_{u1}/N_u$ (N_{Rd1}/N_{Rd}) – the reduction factor of the bearing capacity for the vertical force; $k_V = Q_{u1}/Q_u$ (V_{Rd1}/V_{Rd}) – the reduction factor of the bearing capacity for the horizontal force.

It be seen from the results of the calculation that the greatest loss of the bearing

Table 1. The bearing capacity of the masonry pier before and after the crack formation (according to SNiP II-22-81 [14])

The crack type	N_u, kN	N_{u1}, kN	k_N	Q_u, kN	Q_{u1}, kN	k_V
The cenrtal compression						
Vertical	571,5	440,42	0,771	108,44	96,37	0,889
Horizontal		571,5	1		76,85	0,709
Inclined		525,11	0,919		0	0
The eccentric compression						
Vertical	441,22	157,1	0,356	76,94	32,3	0,42
Horizontal		433,13	0,982		46,52	0,605
Inclined		405,41	0,919		0	0

Table 2. The bearing capacity of the masonry pier before and after the crack formation (according to DBN V.2.6-162:2010 [15])

The crack type	N_{Rd}, kN	N_{Rd1}, kN	k_N	V_{Rd}, kN	V_{Rd1}, kN	k_V
The cenrtal compression						
Vertical	528,56	452,58	0,856	168,54	153,35	0,91
Horizontal		528,56	1		79,28	0,47
Inclined		485,66	0,919		139,56	0,828
The eccentric compression						
Vertical	379,25	169,46	0,447	89,78	34,73	0,387
Horizontal		379,25	1		36,99	0,412
Inclined		348,47	0,919		72,64	0,809

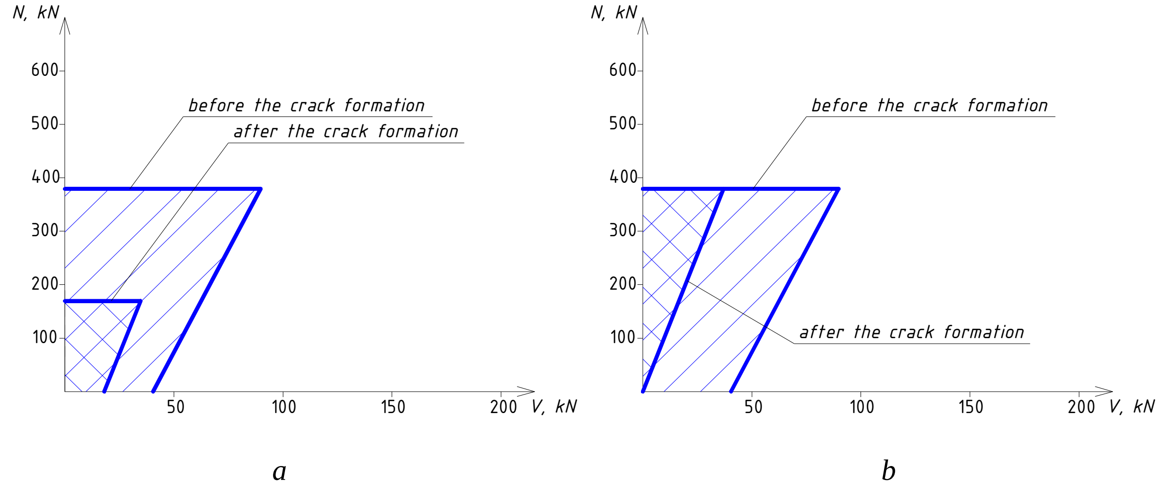

Fig. 2. The graphs of limits of the bearing capacity of the masonry pier before and after the crack formation at the eccentric compression (according to DBN V.2.6-162:2010 [15]): *a* – of a vertical crack, *b* – of a horizontal crack

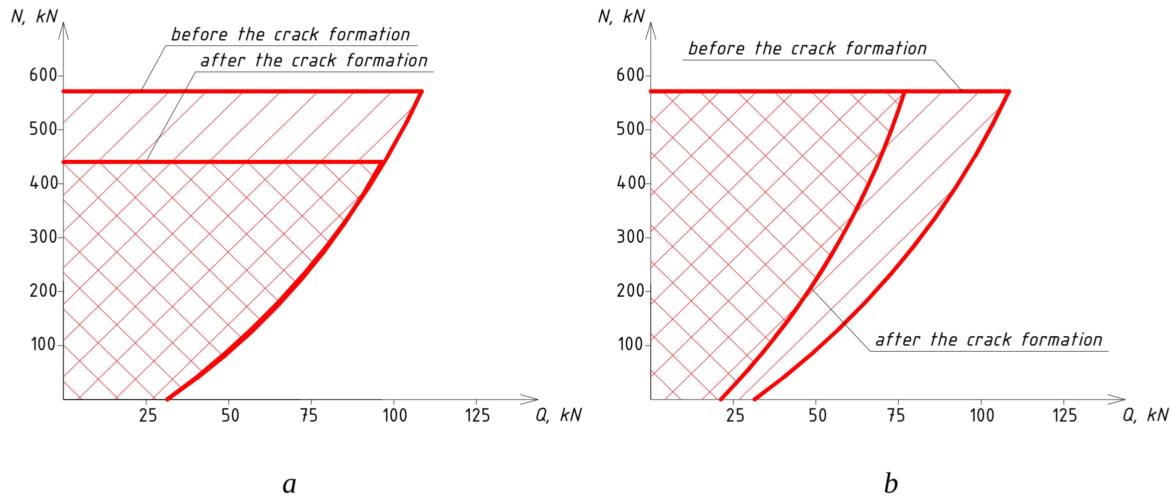

Fig. 1. The graphs of limits of the bearing capacity of the masonry pier before and after the crack formation at the central compression (according to SNiP II-22-81 [14]): *a* – of a vertical crack, *b* – of a horizontal crack

capacity occurs at the eccentrically applied compressive force when there is a vertical through crack (k_N = 0,356, k_V = 0,42 according to SNiP II-22-81 [14], k_N = 0,447, k_V = 0,387 according to DBN V.2.6-162:2010 [15]). This is due to the rapid reduction of the compressed area in both separated parts and a great flexibility in a smaller separated part (with the cross-sectional sizes of 0,51×0,31 m).

A significant loss of the bearing capacity for the shear force also occurs when there is a horizontal crack at the calculation by DBN [15] (k_V = 0,47 at the central compression, k_V = 0,412 at the eccentric one) since in this situation the shear bearing capacity does not include the adhesion force between the separated parts and the friction force is reduced due to the reduction of the maximum compressive stress, which occurs at the decrease of the compression bearing capacity.

Since based on the analyzed provisions regarding the presence of an inclined crack in a masonry element and formula (6) we obtain that when calculating the strength for the principal tensile stresses according to SNiP II-22-81 [14] the cleavage resistance R_{tq} of the masonry is equal to zero, we have that according to these standards the strength for the shear force is equal to zero (Q_{u1} = 0) when there is an inclined crack in the section.

A through horizontal crack does not affect the bearing capacity for the central compression (according to SNiP [14]) and the central and eccentric compression (according to DBN [15]). The slight reduction of the bearing capacity for the eccentric compression according to SNiP [14] occurs due to the effect of the clarified ω factor, which takes into account the cage effect.

Thus, the cracks in the masonry structures and buildings can be taken into account directly and comprehensively when checking their bearing capacity by means of the above approaches.

CONCLUSIONS

In the results of the studies outlined in the paper we can make the following conclusins:

1. The main differences in the chekcs of the bearing capacity between the past and current standards are that DBN V.2.6-162:2010 [15] has no any analogues of the calculation of the principal tensile stresses for the unreinforced masonry.

2. The vertical, through horizontal and inclined cracks in the masonry structures and buildings can be taken into account directly and comprehensively when checking their bearing capacity with the help of the approaches outlined in the paper. The considered methods of taking into account cracks should be further verified by performing the appropriate physical experiments.

3. The greatest loss of bearing capacity 3.The greatest loss of bearing capacity occurs at the eccentrically applied compressive force with the existence of a vertical through crack (k_N = 0,356, k_V = 0,42 according to SNiP II-22-81 [14], k_N = 0,447, k_V = 0,387 according to DBN V.2.6-162:2010 [15]). This is due to a sharp decrease in the area of compressed zones in the two separate parts and a great flexibility in a smaller separated part

4. A significant loss of the bearing capacity of the element of the transverse force is traced at the existence of a horizontal crack according to the calculation by DBN [15] (k_V = 0,47 at the central compression, k_V = 0,412 at the eccentric one) as in the bearing capacity of the shear in this situation the adhesion strength between the separated parts is completely absent and the friction force is reduced due to the reduction of the maximum compressive stress, which occurs at the decreasing of the bearing capacity of the compression.

5. With the existence of an inclined crack there is no strength of the transverse force in the section of the element (Q_{u1} = 0) as when calculating the principal tensile stresses strength according to SNiP II-22-81 [14] the cleavage resistance of the masonry R_{tq} is equal to zero.

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ВЛИЯНИЕ ТРЕЩИН НА НЕСУЩУЮ СПОСОБНОСТЬ КАМЕННЫХ КОНСТРУКЦИЙ

Аннотация. Исследовано влияние различных видов трещин в элементах на их несущую способность, согласно расчетам по прошлым (СНиП II-22-81) и действующим нормам (ДБН В.2.6-162: 2010). Проанализировано влияние трех вариантов трещин в каменных конструкциях – вертикальных сквозных (одинарных, не от перегрузки на сжатие), горизонтальных сквозных и наклонных по штрабе – на несущую способность каменной кладки. Приведен численный анализ несущей способности каменного простенка в начальном состоянии (до образования трещин) и после образования трещин, согласно расчетам по вышеуказанным нормативным документам.

Ключевые слова: каменные конструкции, трещины, несущая способность, центральное и внецентренное сжатие, главные растягивающие напряжения.

Complex mechanization of structural coverage lifting using setting module

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Summary. The analysis of complex installation mechanization using adjusting hoisting module (VPVM) has been conducted. Hoisting systems allow basic assembly operations, namely many single-type operations. Namely: installation of structural coverage, verification of adjusted elements and constructions position, final attaching of the constructions. The main task at high size structural coverage lifting is to increase the productivity of installation. Determination of constructional features during installation using adjusting hoisting module (VPVM). The proposed installation enables the lifting due to the fact that the most labor-intensive operations can be automated. Coverage installation according to the way of lifting jack systems ejecting has the major advantage over existing methods of construction – installation can occur while arranging the permanent supporting elements (columns).

Key words: complex mechanization; hoisting system; assembling/installation; structural coverage.

Hoisting system is a mechanism which allows to perform in cycles basic installation operations and lifting techniques (movement) with the help of a single or multiple lifting jacks, as well as placing and installation of structural coverage in the project. Adjusting hoisting modules have several advantages over other mechanization systems of lifting large-size coverage, namely, they allow the workers, for the whole period of constructing, to perform many single-type operations and techniques: installation, concreting, verification, placing, welding, bolts installing, etc. The most labor-intensive operations can be automated, such as lifting and moving lifting jack systems. The number of units depends on the total weight of the coverage and is determined by calculation. Installation of the devices on the columns is performed at low project marks, directly before lifting coverage after completion of the final consolidated collection.

The list of basic operations and methods of conducting the consolidation of high-size covering structures and installation of lifts are defined by the engineering maps. The list of basic operations for at low coverage scaffold include:

- installation of high-size covering structures according to the technology bundling in the engineering map;
- verification of adjusted elements and constructions position;
- temporary and final attaching;
- installation of adjusting hoisting module (lifts) on all columns that will serve as operational;

• verification of adjusting hoisting modules and attaching them for inclusion in the further operation.

Lifting of the covering is performed with the help of legged locomotion hoisting modules cyclically while arranging permanent columns. This technology allows to perform consistently (due to the specially designed program the following cycles of blocks or coverage mounting, such as:

• lifting of the coverage to the height of the stroke of lifting-jack piston;

• assembling and temporary attaching the following element on the head of the bearing column (lifting height is due to the calculation, depending on the scheme and the establishment of jacks and it should be sufficient for installing the column element in project position);

• verification – determines the position of the block in plan, down, across; captures, monitors and ensures adherence of the project requirements; controls corresponding correcting by the deviations;

• attaching and transfer of the load from the covering on the new column head; consistent repeating of all the cycle operations with the covering installation to achieving the intended design point. The number of cycles is determined by the ration of the project point height to the column element height.

The adjusting/setting hoisting module:

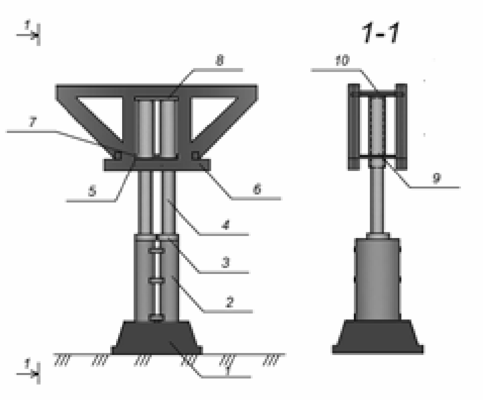

Fig. 1. The adjusting/setting hoisting module (1 - 1 – the setting hoisting module section): *1* – base, *2* – column, *3* – jack foot, *4* – jack rod, *5* – band for the lower stopper, *6* – frame *7* – lower stopper, *8* – top stopper, *9* – jack, *10* – try square

The work on establishing VPVM perform in the following way:[2]

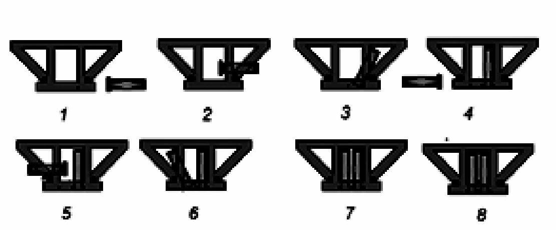

Fig. 2. Collection (VPVM: *1*- preparation of the 1st legged hoisting module lifting jack installation; *2*- installing of the 1st lifting jack due to the turning regarding the 1st point of turn, *3*- installing of the 1st lifting jack due to the 2nd point of turn, *4*- preparation of the 2nd lifting jack, *5*- installing of the 2nd lifting jack due to the turning regarding the 1st point of turn, *6*- installing of the 2nd lifting jack due to the turning regarding the 2nd point of turn, *7*- installing of the set that keeps the legged hoisting module lifting jack, *8*- the final form of the legged hoisting module (VPVM)

The way of installing the facilities covering using (VPVM):[3]

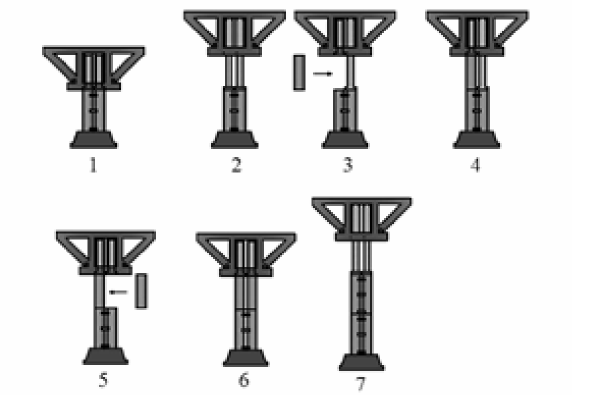

Fig. 3. Lifting stages (VPVM),: 1 - the original condition of the legged hoisting module (VPVM), *2* - the start of the hoist cycle (VPVM), 3- withdrawal of the first hoist rod (VPVM), *4*- the assembling and fastening of the first part of the column, supporting of the first part of the column by the first rod, *5*- withdrawal of the second hoist rod (VPVM), *6*- the assembling and fastening of the second part of the column, supporting of the second part of the column by the second rod, *7*- beginning of the next cycle of hoist work (VPVM)

Work on the VPVM dismantling is performed as follows:[3]

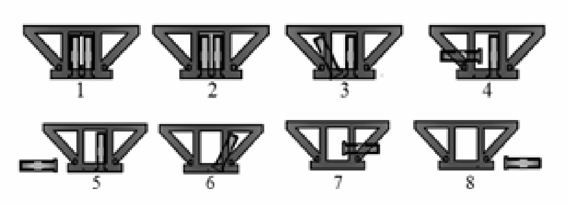

Fig. 4. Dismantling **(**VPVM),: *1*- the original form of the setting hoisting module (VPVM), *2*- withdrawal of the mounting holding setting hoisting module lifting jack (VPVM), *3*- pushing the 1st lifting jack 1st through the 2nd turning point, *4*- pushing the 1st lifting jack due to the turning regarding the 1st point of turn, *5*- complete removing of the first jack, 6- pushing the 2nd lifting jack through the 2nd turning point, *7*- pushing the 2nd lifting jack due to the turning regarding the 1st point of turn, *8*- removal of 2nd setting hoisting module lifting jack (VPVM)

The sequence of stages fulfillment:

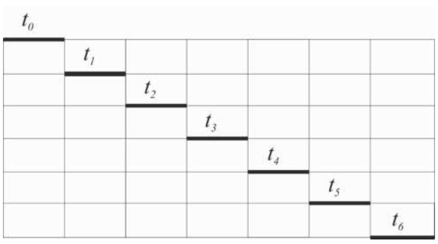

Fig. 5. The scheme of stages completion sequence

Here the value of time $t_0 \ldots t_6$ – meet stages of installation work sequence 0...6. Thus: the duration of the zero cycle preparation does not affect the speed of installation covering, but only determines the start of the lifting cycle. Initial fastening of the hoist on the support element head with the work duration *t*1 depends [30…30/3] on the method of installation work and is reduced through increased mechanization level at the section [5]. This level (%) is found with the following formula:

$$\text{У}_{MP} = \frac{\text{У}_{MT}^{\mathrm{I}} \cdot d_0^{\mathrm{I}} + \text{У}_{MT}^{\mathrm{II}} \cdot d_0^{\mathrm{II}} + \ldots + \text{У}_{MT}^{n} \cdot d_0^{n}}{100},$$

Where d_0 is the level of operation mechanization,%: У_{MT} is the specific weight of the operation;

$$\text{У}_{MT} = \frac{t_M}{t_0} \cdot 100,$$

where t_M is the spending of mechanized labour on the operations completion using selected mechanization methods, person/hour; t_0 – general labour intensity of the operations completion, pers./hour.

•t_2 – “coverage lifting” is characterized by the ratio of the velocity of the hoist to a modular step of the supporting elements:

$$t_3 = \frac{V_{П}}{l_K + l_{МП}},$$

where l_K is a modular step of the supporting element; $l_{МП}$ is the mounting limits height.

In contrast to the proposed lifting method, t_2 is sufficiently influenced by external natural factors: wind, ice, moisture etc, when lifting the load with the help of the devices with flexible link (the method of pulling up). When selecting values for module step l_K one should consider the following: an increase in the value of step reduces the total time of installation, however, it reduces the stability of constructions at the in-process stages and increases the size of the mounting devices. Conversely, though excessive reduction of the modular step leads to the construction resistance, however it significantly increases the duration of the installation and the material capacity of the supporting elements, because of the presence of a big quantity of elements in the bearing element.

The present study found that the best value modular step l_K is 0,8 ... 1,2 m.

• The duration of the stage 3, corresponding t_3, depends on the level of mechanization of the operation elements.

• The duration of stage 4 can be approximately determined by the formula:

$$t_4 = \frac{V_{П}}{l_{МП}},$$

where $l_{MП}$ is the mounting limits height, *m*.

• The duration t_5 of the phase 5 depends on the lifting lack speed characteristics:

$$t_5 = \frac{V_П}{l_P},$$

where l_P is the value of the hydraulic cylinder rods moving forward at which the output of the forks from the projection of the supporting elements occurs, m; the duration t_6 of the stage 6 is determined by the speed characteristics of the lifting mechanism. Empirically found that the velocity of rods pulling in V_B is determined by the formula:

$$V_B = V_П (1{,}5...2{,}0).$$

At the projecting stage it is necessary:

1. To determine the construction features of the high-size covering and places of its leaning on the supporting element head, coverage weight, maximum spans a and b, and projected coverage lifting height H.

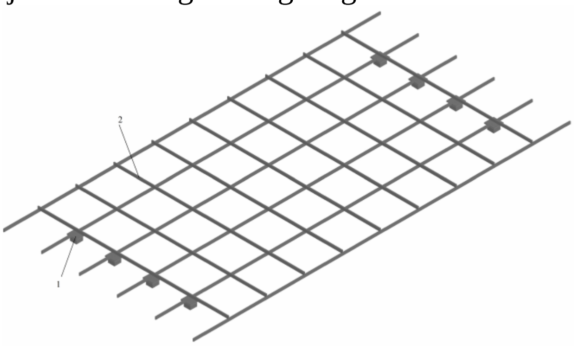

Fig. 6. The calculating covering scheme: *1* - lifting jack, *2* - covering

2. To set the operating parameters of the hoist hydraulic system due to the jack technical indicators (nominal pressure p_H and the flow of the working fluid Q_H) and to select power hydraulic cylinders according to the data.

3. To determine the necessary quantity of hoist devices and their technical characteristics (according to the number of resistance places of the high-size coverage (number of columns or supporting elements) that would satisfy the following essential requirements defined: load-carrying capacity

$$G_П = G_K / n,$$

where *n* is the number of jacks (in the case of the use of proposed hoist device for the conditions of lifting large-covering shown in Figure 6), distributed between 2 hydraulic cylinders $G_П = 4F_Ц$, lifting velocity (Fig. 7) $V_П$

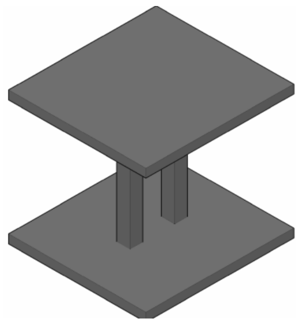

Fig. 7. The calculating lifting device scheme

The allowable load by the calculations for resistance should not exceed the value:

$$P \le \frac{P_{KP}}{n_y}.$$

We believe that the load forcing the rod is static, then we can use the formulae to calculate the critical (Euler) forces (Fig. 8) for the analysis of rod resistance.

This condition should be kept:

$$\sigma_{KP} = \frac{P_{KP}}{F} = \frac{\pi^2 E}{\lambda^2} \le \sigma_П,$$

where – σ_{KP} critical pressure; F – cross-sectional area; E – modulus of longitudinal elasticity of the material (E=2·10^5 for steel materials); $\lambda = \mu l / i_{\min}$ – the flexibility of the longitudinal rod when bending lengthwise; $i_{\min}$ – the smallest radius of inertia of the cross section; μ – coefficient of the given length (μ=2); 1 – the length of the rod.

In general case of the compressed homogeneous rod, the critical force is determined:

$$P_{KP} = \eta \frac{EJ_{\min}}{l^2} = \frac{\pi EJ_{\min}}{(\mu l)^2}$$

where $J_{\min}$ – is the smallest of the main central moments of inertia of the section; L- full rod length; $\eta = (\pi/\mu)^2$ – the coefficient of the critical load.

In view of the above given materials, we find the maximum height of load-lifting with the help of the jack systems.

$$l = \sqrt{\frac{\pi EJ_{\min}}{P_{KP}\mu^2}}.$$

When lifting load the cylinder rod works for compression. Strength condition:

$$\sigma_{CT} = \frac{F}{\pi d^2/4} \le [\sigma_{CT}].$$

Consequently, the diameter of the rod can be determined from the expression

$$d = \sqrt{\frac{4F}{\pi[\sigma_{CT}]}}.$$

The safety factor of stability

$$[S]' = 1{,}25[S],$$

Where [S] is the coefficient of safety, [S]=3.

We can determine the diameter of the rod with Euler's formula (taking into consideration the maximum height of lifting jack)

$$d = \sqrt[4]{\frac{64\mu^2 l^2 F_{KP}}{\pi^3 E}}.$$

Effort on the hydraulic cylinder rod is given by the formula:

$$F_{Ц} = p_H \cdot S_П,$$

where p_H is the nominal pressure in hydraulic drive, Pa; $S_П$ is the area of the piston in the pressure chamber, m^2,

$$S_П = \pi \cdot D^2/4,$$

where D is the diameter of the piston in the pressure chamber, m.

Under the terms of GOST 12445-80 the values are selected from a number of normal values of the nominal pressure:

p_H = [6,3 ...; 10; 12.5; 16; 20; 25; 32; 40; 50; 63 ...] MPa.

Then the values are determined from a number of normal values of the piston cylinder diameters to the GOST 6540-68 conditions:

D = [... 150; 160; 180; 200; 220; 250; 280; 320; 360...], mm.

In the given figure the curves show the actual efforts data on the hydraulic cylinder rod by changing the diameter of the piston at different pressures.

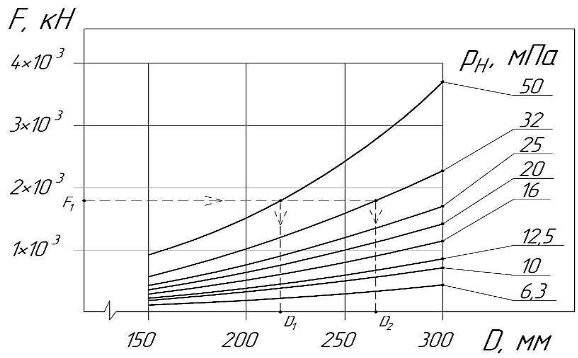

Fig. 8. Dependence of the actual efforts on the hydraulic cylinder rod on the diameter at pressures from 6.3 to 50 MP

Conclusion: A new lifting jack system is a device and method having advantages over other systems of mechanization of lifting large-coverings, namely, provides the workers (for the duration of lifting coverage) with many of the single-type operations and techniques: installation, concreting, verification, placing, welding, bolts installing, etc. And the most labor-intensive operations can be automated, such as lifting and moving lifting lack systems. The proposed adjusting hoisting module (VPVM) enables step-by-step lifting due to the fact that the installation can take place while arranging the permanent supports (columns).

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КОМПЛЕКСНАЯ МЕХАНИЗАЦИЯ ПОДЪЕМА СТРУКТУРНЫХ ПОКРЫТИЙ ГРУЗОПОДЪЕМНЫМ УСТАНАВЛИВАЮЩИМ МОДУЛЕМ

Аннотация. Выполнен анализ комплексной механизации монтажа с помощью грузоподъемного устанавливающего модуля (ВПВМ). Грузоподъемные системы позволяют выполнять основные монтажные операции, а именно много однотипных операций. А именно: монтаж конструкций покрытия, выверка положения элементов и конструкций, монтировались, окончательное закрепление конструкций. Основной задачей при подъеме крупноразмерных структурных покрытий является повышение производительности монтажа. Определение конструктивных особенностей при монтаже с помощью грузоподъемного устанавливающего модуля (ВПВМ). Предложенный монтаж позволяет выполнять подъем за счет того, что наиболее трудоемкие операции могут быть автоматизированы. Способ монтажа покрытия методом выталкивания домкратными системами имеет основное преимущество над существующими методами возведения - монтаж может происходит с одновременным устройством постоянных опорных элементов (колонн).

Ключевые слова: комплексная механизация, грузоподъемные системы, монтаж, структурные покрытия.

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Principles of classification of geological processes

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Summary. In this paper, basic geological processes and factors affecting the formation and activation of geological processes are discussed. With consideration for the effects of these factors, the classification system for geological processes is proposed. In order to more objectively estimate geological processes according to this classification system, the classification schemes of exogenic and endogenic processes have been developed. These classification schemes may be used in the analysis of geological processes, in respect with the engineering measures for preparation and protection of urban areas with complex engineering and geological processes selection evaluation.

Key words: geological process, exogenic process, endogenic process, cryogenic process, eolian process.

INTRODUCTION

The enhancement of the density of the urban areas, the development of the areas with difficult terrain are leading to the changes in geological and hydrogeological processes in such areas. In most cases, any changes in existing geological conditions cause deformation of ground surfaces.

The works for protection and development of land, which are necessary in order to ensure comfortable living conditions for urban population, are high-priority and first-order problem in the reconstruction and development of urban territories.

Therefore, the activities in studying conditions for the development, extension, activation, and control of geological processes are also considered as high-priority and urgent issues.

Geological processes are of interest with respect to protection, development, planning, and management of urban territories, as such processes affect existing and design buildings and structures.

At the present time, the land plots that are actively used in urban development include land plots, both low-convenient and inconvenient for construction, where geological processes are present, were present, or could be present in favorable conditions.

ANALYSIS OF PAST STUDIES AND PUBLICATIONS

The results of the analysis of geological processes have been discussed in various publications and attracted attention. At the present time the local classification systems with respect to geological processes, and causes of geological processes are being analyzed, and basic principles and methods of protection against negative effects of geological processes have been determined.

Geological processes have been studied by such domestic and foreign researchers as Savarenskiy F.P., Kolomenskiy M.V., Nayfeld L.R. [4], Vladimirov V.V. [5], Nazarenko I.I. [7], Nishchuk V.S. [8], Bakutis V.E. [6], Kaplan L.Z. [9], Gorshkov G.P. [17], Peredelskiy L.V. [14], Sergeyev E.M. [12] and Lomtadze V.D.

STATEMENT OF THE PROBLEM

The purpose of this paper is implementing the classification system for geological processes having effect on the development of urban territories, determining new methods for solving problems; developing and using of classification schemes as means for ensuring quality and efficiency of activities in solving problems associated with the means for information support, research activities, science-based complex engineering solutions, and methods with respect to the development of urban territories subjected to the effects of geological processes.

Only complex studies of geological processes can provide the possibility to obtain improved knowledge about the characteristics and causes of geological processes, as well as methods for predicting geological processes.

CLASSIFICATION OF GEOLOGICAL PROCESSES

The term *"geological process"* means a change of components of the geological environment in time and space under the influence of natural and technogenic factors [20].

Depending on the source of changes or forces causing dynamic forces these processes are divided for the internal endogenic processes, and external exogenic processes. Therefore, the first stage in studying geological processes is to divide the geological processes and develop their classification (see Figure 1).

Lets consider in more detail each group of geological processes.

Endogenic processes are caused by changes within the internal geological structures of the Earth, that is, within the lithosphere, mantle, and core of the Earth. Endogenic processes result from internal forces inside the Earth and virtually do not depend or lowly depend on external factors. Endogenic processes promote tectonic stresses of the Earth crust and, for this reason, are associated with various processes which cause the nonuniformity, expansion, and bedding or rocks [16].

Exogenic processes are characterized by changes of rocks and mountain structures and general appearance of the earth surface under the influence of the energy of the sun, planets of the solar system, and space environment [16].

The basic sources of the energy of exogenic processes are the continuous movement of water and air masses, circulation of water in the atmosphere, on the earth surface, and in the entrails of the Earth, chemical and physical transformation of substances under the influence of the vital activity of living organisms, and human activity. Therefore, any exogenic process is characterized by the following three stages of development: destruction, transfer, and deposition of materials.

Exogenic processes are interconnected. The formation of any exogenic process causes the formation of another exogenic process. Therefore, only analysis of exogenic processes in combination allows all changes on the Earth surface to understand and the laws to which s changes are subjected to determine. This conclusion applies also to both the exogenic and endogenic processes. These

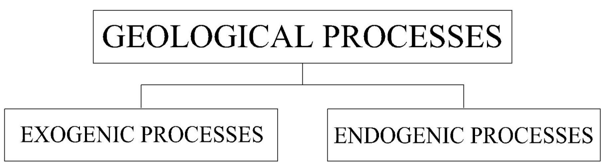

Fig. 1. Classification of geological processes

processes are interconnected and, accordingly, represent the complexity, diversity, and, at the same time, the unity of the dynamic forces acting on the Earth.

The most important feature of geological processes is the nonuniformity of their effects on the earth surface in different districts and regions due to different physical and geographic conditions, surface relief, rock anisotropy, and location of tectonic structures [16].

All geological processes occur and vary depending on the characteristic actions and mode of interaction of underground tectonic processes, stressed-deformed state of rock masses, changes of rock properties, temperature conditions at the upper part of the earth crust and at the earth surface, hydrogeological conditions, and surface water. Such effect of diverse factors affecting the formation of natural, technogenic, and combined geological processes is the characteristic feature of geological processes.

While studying geological processes, the causes of and the conditions for the formation of geological processes were determined. The factors that directly promote the formation of geological process in a favorable environment may be used in grouping geological processes and creating groups with common characteristics.

For the first time, the classification of geological processes and events was proposed by F.P. Savarenskyi in 1937. The classification system developed by F.P. Savarenskyi in 1941 was based on the diversity of causes of formation and development of geological processes and events. Later, this classification system was complemented by M.V. Kolomenskyi in 1956. The classification system effective at the present time is presented in Tab. 1.

In the proposed classification system, the causes of geological processes and events are indicated. Due to this, the classification system has practical value, as the actions required for protection against these processes and events shall be focused, first of all, on the removal of the causes and consequences of the processes and events. If such removal is not possible, for example, in case of earthquakes, the actions shall be focused on re-

Table 1. Classification of geological processes

Nr.	Cause of occurrence and development of a geological process or event	Geological process or event
1	Activity of factors inducing weathering	Weathering
2	Activity of surface water (sea water, lake water, river water, channel water)	Underwashing and slide of banks (marine and fluvial abrasion) Water erosion of slopes (formation of ravines and gullies), earth flow
3	Activity of surface and underground water	Swamp formation, subsidence, karst formation
4	Activity of surface and underground water on slopes	Rock displacement
5	Activity of underground water	Subsoil erosion, shifting sand
6	Freezing and thaw of soil	Freezing and thawing of soil Permanently frozen soil and its effects
7	Activity of internal forces of Earth	Seismic events
8	Industrial activity of human beings	Land subsidence, compaction, bulking. surface and underground deformations in mine openings

ducing the effects of processes and events on buildings and structures.

The results of the studied sources analysis were used for the classification of geological processes with consideration for the basic affecting factors.

I. Exogenic processes:

1. Processes associated with climatic factors.

2. Processes associated with activity of surface water.

3. Processes associated with activity of underground water.

4. Processes associated with activity of gravitational forces on slopes.

5. Processes in regions with permanently frozen soil (cryogenic processes).

II. Endogenic processes:

1. Processes associated with activity of internal forces of the Earth.

The classification of geological processes is performed with consideration for factors that cause the formation and development of processes. The final result of the study of geological processes consists in the development of the classification scheme of processes (see Figs. 2 and 3).

In developing the classification schemes, the basic factors to be considered are factors of natural origin. Anthropogenic factors are not considered.

The processes associated with climatic factors are weathering and eolian processes (deflation, corasion, denudation, and accumulation).

These processes are characterized by changes in rocks and rock minerals in the thermodynamic conditions on the earth surface under influence of natural factors.

Eolian processes are processes of blowout, transfer, and accumulation of sandy and silty rocks under action of wind.

The geological action of wind appears as *deflation, corasion, denudation, and accumulation*.

Eolian processes cause the formation of specific objects of surface relief, such as barkhans, barkhan patterns, sand ridges, dunes, and hilly sands [16].

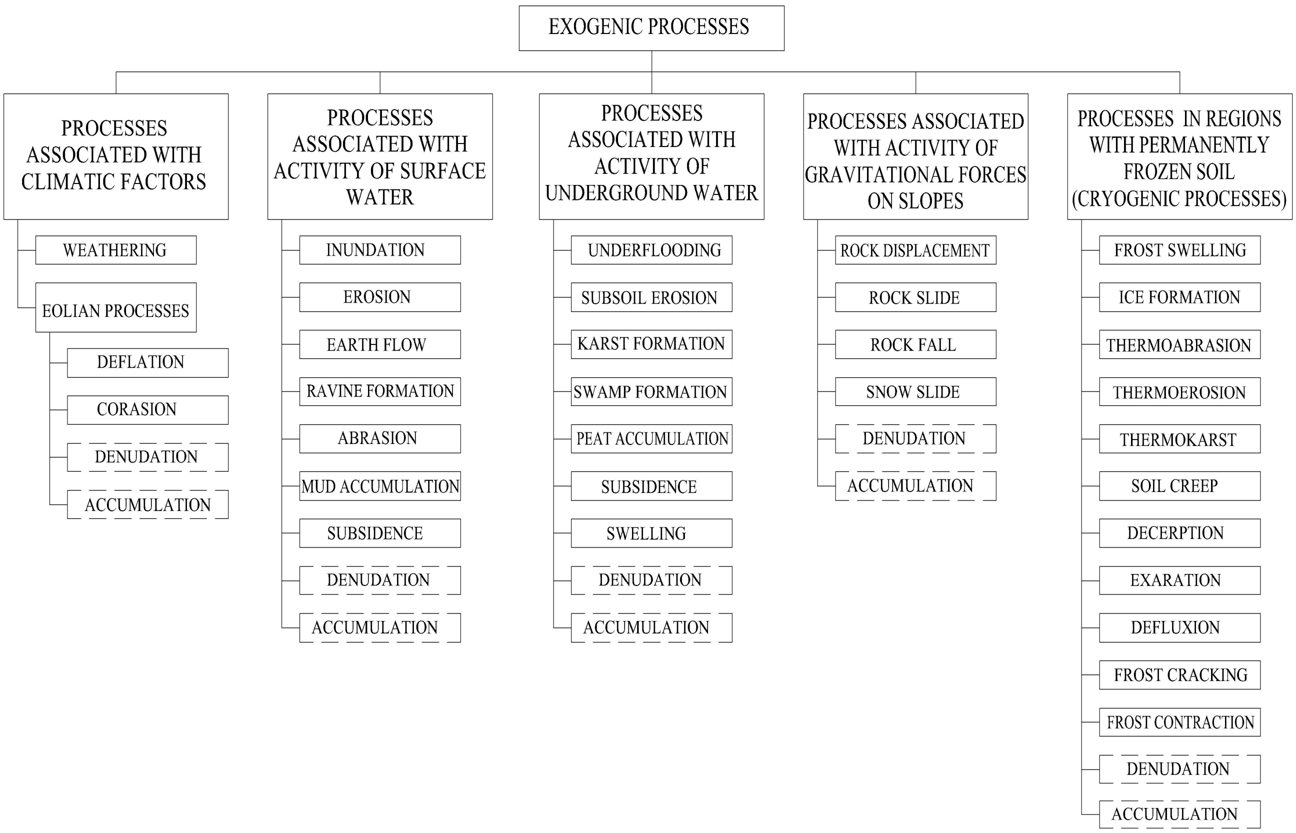

Fig. 2. Classification scheme of exogenic geological processes

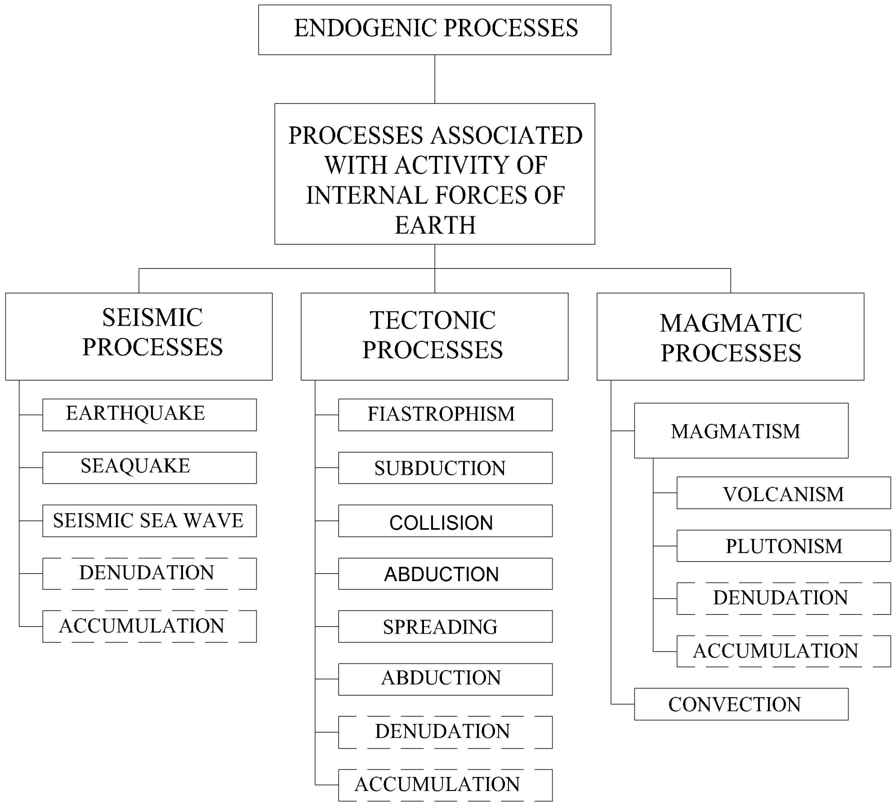

Fig. 3. Classification scheme of endogenic geological processes

The classification schemes include repeated processes, for example, denudation and accumulation processes. This repetition is possible due to that these processes are formed under some elements: the effect of climate, surface and underground water, gravitational forces, and internal forces of the Earth. The process results in the movement of material from the higher areas to the lower areas of the surface relief. Denudation processes cause changes in the surface relief that promote the relief leveling. Denudation processes include processes that are formed in the result of climatic factors (eolian processes such as deflation) and activity of surface water (inundation, erosion, earth flow, abrasion), activity of underground water (subsoil erosion, karst formation), and activity of gravitational forces on slopes (rock displacement, rockslide, snow slide), and processes in areas with permanently frozen soil (cryogenic processes, such as ice formation, soil creep, thermoabrasion, thermokarst, thermoerosion, and exaration).

In the process of transfer of products of rock degradation, the products accumulate according to the size, density, and chemical composition of the products. The accumulation of products of rock degradation and formation of rocks occur at settlings of the surface relief, therefore, the final stage of the corresponding processes is accumulation.

The processes associated with activity of surface water include inundation, erosion, earth flow, ravine formation, abrasion, mud accumulation, and subsidence.

These processes are characterized by a free water surface on land plots due to the increase of water levels at waterways and water storage reservoirs and due to the accumulation of water at settlings of the surface relief. In this case, both the permanent and temporary formation of a free water surface is possible. As a result, rocks are being destructed due to water flow or land drainage.

The effects and activation of this group of processes result in formation of unfavorable surface relief.

The main medium that activates these processes is surface water.

The processes associated with activity of underground water include underflooding, subsoil erosion, karst formation, swamp formation, peat accumulation, subsidence, and swelling.

These processes are characterized by their effects in certain conditions of the natural environment, including urban environment, and are caused by various factors having natural and technogenic origin, specifically due to the increase of the soil humidity or ground water level to the limit values beyond which the environmental conditions become unfavorable.

The main medium that activates these processes is underground water.

The subsidence processes are caused by different factors promoting these processes. For this reason, these processes pertain to both the group of "processes associated with activity of surface water" and the group of "processes associated with activity of underground water". The main media for the subsidence processes are surface and underground waters.

The processes associated with activity of gravitational forces on slopes include rock displacement, rock slide, rock fall, and snow slide.

These processes are characterized by the relatively slow or, in specific cases, fast movement of earth masses, rock fractions, or snow masses down the hill slopes due to the change of physical properties of hills and action of surface and underground waters as well as atmospheric precipitation.

The causes of reduction of the resistance of a slope to these processes can be overload of the slope surface, underwashing of the slope base due to abrasion, or decrease of the strength of rocks in some layers due to the increase of the ground water level or decrease of filtration pressure to the rocks.

The *cryogenic processes* are represented by thermophysical, mechanical-and-physical, and chemical processes in frozen and thawed grounds and ground rocks [20].

Frozen water present in soils and rocks and seasonal and daily changes of the aggregative state of the water cause various cryogenic processes.

Such cryogenic processes are: the frost swelling, ice formation, thermoabrasion, thermoerosion, thermokarst, soil creep, decerption, exaration, defluxion, frost cracking, and frost contraction.

The extent and intensity of the cryogenic processes depend on atmospheric precipitation characteristics, heat and moisture exchange in the upper layers of rocks, and dynamical characteristics of freezing and thawing.

Cryogenic processes occur in combination and interact with other exogenic processes. These processes have different effects in denudation, accumulative, and relatively stable areas.

In mountain areas, where denudation grounds are dominant, weathering products, such as column-like rocks of irregular shape, and exaration – the stone streams as deposits of stony or crushed stone material are formed. On mountain slopes, stony terraces and strips are formed. If the slope contains soft rock deposits, solifluction surface relief can be formed in cases when the thawing surface soil layer creeps down. The characteristic feature of horizontal surfaces and flat beds is the formation of structural surface relief represented by such equitable polygonal objects as stony polygons, rows, rings, and other like objects with a diameter from 10 cm to several meters. Such structural relief appears due to seasonal changes, when the surface ground water freezes in autumn, with the formation of polygonal cracks and soil swelling, and in winter, frozen ground fractions are squeezed out to the surface. In spring, such fractions move downhill and accumulate in polygonal cavities. This cycle will be repeated in the subsequent year.

The effects and activation of this group of processes result in formation of unfavorable surface relief.

The processes associated with activity of internal forces of the Earth include seismic processes (earthquake, seaquake, seismic and sea wave), tectonic processes (fiastrophism, subduction, spreading, and rifting), and magmatic processes, such as magmatism (volcanism and plutonism) and convection.

These processes are characterized by changes occurring due to the abrupt release of the potential energy of the earth interior, including elastic vibrations and movement of lithosphere plates.

In such cases, the change of the parameters of any process can cause the activation and effects of other processes. This feature is characteristic for both the exogenic and endogenic processes.

CONCLUSIONS

The proposed classification system is the basis for the further studies of geological processes. The ground is the systematization of geological processes by developing of the classification schemes that will enable an objective assessment of the areas conditions subject to the influence of certain geological processes, combining them into blocks according to certain criteria and, as a result, making optimal engineering decisions when selecting methods of engineering protection. In the development of the classification schemes are considered the factors promoting effects or activation of geological processes.

The developed classification schemes can be used effectively in carrying out the engineering and construction estimation of territory, engineering preparation and protection of territories, design documentation elaboration (of stages "P", "RP", "R", etc.):

- districts and regions;
- general localities plans (towns, villages and settlements);
- detailed plans of territories.

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ПРИНЦИПЫ ПОСТРОЕНИЯ КЛАССИФИКАЦИИ ГЕОЛОГИЧЕСКИХ ПРОЦЕССОВ

Аннотация. Рассмотрены основные геологические процессы, факторы влияния на их активизацию. Учитывая признаки действия основных факторов, влияющих на формирование процессов, разработана классификация геологических процессов. Для более объективной оценки этой классификации разработаны модели экзогенных и эндогенных процессов. Предложено использование разработанных моделей при анализе и изучении геологических процессов, принятии инженерно-планировочных решений.

Ключевые слова: геологический процесс, экзогенный процесс, эндогенный процесс, криогенные процессы, эоловые процессы.

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