

BUILDING CONSTRUCTION, BUILDINGS AND STRUCTURES

STRUCTURAL SOLUTIONS FOR STRENGTHENING DAMAGED STONE ARCH STRUCTURES

V. V. Pavlov, E. V. Khorkov

Annotation. We considered the historical aspects of the emergence of stone arched structures of ceilings, the materials used for their construction in various historical periods, the classification of arched structures, as well as the main design solutions and technological aspects of their construction. We present the results of the work performed to determine the numerical values of geometric parameters and to survey the technical condition of arched structures of old buildings located in the central (historical) part of Kazan. As well we demonstrate the results of a study of the works of other authors to determine the most common defects and damages in arches and the causes of their occurrence. We show the technical solutions of various authors to strengthen arched structures using various materials, including composite materials based on unidirectional carbon fibers. We describe the scope of application and outline the technical solutions developed by the authors of the article for strengthening arched structures that take into account the features of their design solutions and damages.

Keywords: arch; sprung structures; defects; damage; reinforcement; restoration.

ENGINEERING SYSTEMS AND COMMUNICATIONS

DEVELOPMENT OF ADAPTIVE VENTILATION IN MULTIFUNCTIONAL LARGE-SCALE SPACE OF PUBLIC BUILDINGS

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Annotation. We analyzed the relevance of cultural facilities construction. As well, we described the expediency of designing multifunctional transformable spaces for public buildings. Moreover we presented advantages and disadvantages of using air recirculation as a method of energy saving. A special attention is focused on maintaining indoor air clean and on various ways of combatting bacteria and viruses in the intake air. We offered a scheme of multi-zone forced air ventilation without recirculation with blocking air conditioners for interchangeability in order to provide a microclimate in multifunctional spaces of public buildings. We described the sequence of operations in the ventilation system in warm and cold seasons. We also developed a recuperation system with an intermediate refrigerant for warm seasons. The article presents a detailed description of the air conditioning unit operation. We carried out a numerical study of the operating modes of the ventilation

system with heat and cold recovery for transformable spaces on the example of a real-existing facility. We show a graph to determine the boundary conditions of the recuperator operation based on the ratio between the intensity of heat transfer due to convection and the intensity of heat transfer due to thermal conductivity. At various outside air temperatures and design temperatures of the outgoing air, we created some graphs for determining the optimal parameters of the air temperature at the inlet to the heat exchanger at the optimal values of the water equivalent. We identified and described several modes of operation of air conditioners with a heat exchanger in warm seasons, operating as part of a multi-zone forced air ventilation with blocking air conditioners for interchangeability. In the course of a numerical study, it was revealed that the highest energy efficiency of a ventilation system with a recuperator could be achieved when the water equivalent value $W = 3$ is taken as the optimal value.

Keywords: heat exchanger; heat recovery unit; boundary conditions; intermediate heat carrying agent; variable air flow; temperature.

EXPERIMENTAL STUDIES OF CARBON DIOXIDE INTAKE INTO THE ROOM FROM A PERSON ENGAGED IN MENTAL WORK

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Annotation. Intellectual work is quite diverse and is characterized by different degrees of responsibility, monotony, attention, the level of emotional tension. In order to ensure comfortable conditions for a person staying at a permanent workplace among other things it is necessary to arrange climate control systems. The most promising ventilation systems for the above activities are personal ones that provide high-quality air environment in the breathing zone of a person while reducing capital and operating costs compared with traditional types of ventilation systems (mixing, displacement ventilation). However, the design of such systems should be guided not by the "average conditional person" but by the individual characteristics of the worker (age, gender, etc.) performing a particular type of mental activity. In order to clarify the actual value of carbon dioxide emitted by a person doing a particular mental work, we conducted a series of field experimental studies. They resulted in confirmation of the nature and dynamics of changes in carbon dioxide in the room in the absence (inactivity) of ventilation systems (linear dependence). As well we clarified the value of emitted carbon dioxide at a particular type of mental activity (in this article we studied the work of an engineer-designer).

Keywords: carbon dioxide concentration; microclimate; personal ventilation; mental work; comfortable air parameters.

DETERMINATION OF CHEMICAL AND TOXICOLOGICAL CHARACTERISTICS OF WATER QUALITY IN RECREATIONAL AREAS ON THE MATYRA RIVER

E. Yu. Ivanova

Annotation. The paper presents and analyzes the data of chemical and toxicological studies of the water of the Matyra river of the Lipetsk region. Excess of permissible values for organoleptic parameters, as well as for sulfates, ammonium ion and nitrites were noted. In addition, the relative toxicity was determined using a method based on the registration of changes in the optical density of the *Chlorella* (*Chlorella vulgaris*) algae culture. The results of the bioassay showed that all water samples demonstrated toxicity, which manifests itself in stimulating the growth of chlorella culture. Such growth stimulation indicates that the samples studied contain easily digestible organic and inorganic compounds. When comparing the obtained concentration values with previous studies, negative dynamics was noted for all identified pollutants, which indicates a decrease in water quality.

Keywords: the Matyra River; surface waters; chemical analysis; bioassay; toxicity.

CITY. RECONSTRUCTION, RESTORATION AND LANDSCAPING

METHODOLOGICAL APPROACH TO THE ASSESSMENT OF THE HEDGE STRUCTURE IN THE URBAN IMPROVEMENT SYSTEM

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Annotation. We determined the importance of timely consideration of the quality and condition of hedges as a multifunctional element of the urban landscape. The existing inventory methodology does not take into account the common problems of hedges. The authors' methodology effectiveness is in the simplicity of accounting, where the visible problems of the hedge structure (gaps parameters) are recorded and the clarity of the calculated data is obtained. That allows us to comparatively assess the quality of hedges and choose an adequate strategy to improve their condition. The concept of general hedge integrity is introduced, which shows the specific length of hedge sections not disturbed by gaps, expressed as a percentage. The method has been tested on 19 public facilities in the central district of Yoshkar-Ola city. Violations of the structure of hedges were revealed: a decrease in their integrity due to the presence of gaps in an amount from 0.2 to 2 pcs. per 10 running meters and with length from 0,7 to 4,8 running meters. Different lengths of gaps require different approaches to their recovery.

Keywords: assessment methodology; hedge; Yoshkar-Ola city; green spaces; integrity; gaps.

ECOLOGY AND SAFETY OF THE URBAN ENVIRONMENT

MONITORING THERMAL POLLUTION SOURCES IN VORONEZH (RUSSIA) USING REMOTE SENSING DATA

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Annotation. The study deals with the remote sensing and monitoring of urban heat islands. We present a methodology of multispectral satellite imagery selection and processing. The study bases on the freely available Landsat 8 TIRS data. We used multitemporal thermal band combinations to make maps of the urban heat island of Voronezh (Russia) during summer and winter periods. That let us identify 11 artificial sources of heat in Voronezh. All of them turned out to be allocated within industrial zones of plants and water treatment facilities. Land surface temperatures (LST) of these sources were approximately 6° and 15.5° C above the background temperatures in winter and summer, respectively. To prove the remotely sensed temperatures we conducted ground control measurements of LST of different surface types at the satellite revisit moments. Our results showed a significant correlation between the satellite and ground-based measurements, so the maps we produced in this study should be robust. They are of use in urban planning and medical ecology studies.

Keywords: GIS; remote sensing; urban heat island; urban climate; Landsat 8 TIRS.

TECHNICAL AND METHODOLOGICAL JUSTIFICATION OF THE ORGANIZATION OF SELECTIVE COLLECTION OF MUNICIPAL SOLID WASTE IN A RESIDENTIAL DEVELOPMENT

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Annotation. We carried out the analysis of the situation with the combined disposal of solid municipal waste (SMW). Due to the fact that the designs of waste chutes used today are not intended for selective (separate) collection of SMW, the article examines the possibility of renovation and modernization of the waste chute and waste collection chamber for selective collection of SMW in the existing apartment buildings. The authors offer a variant of modernization of the waste collection chamber, which consists in the following: in the waste collection chamber there are several containers, instead of a branch pipe and a gate, a single apron is arranged for all containers, equipped with flaps that open for the desired type of waste when the corresponding button is pressed on the control unit. The possibility of organizing street container platform for selective collection of SMW was considered for the apartment buildings which do not have waste chutes. To calculate the size of the required containers, we conducted a study to determine the mass and volume of different SMW fractions per person. According to the results of the study, a calculation

was made for the selection of container sizes for all types of waste for the waste collection chamber and for the street container site, with the determination of the frequency of SMW removal. An algorithm for selective collection of SMW in existing residential buildings has been developed.

Keywords: municipal solid waste; sorting; separate waste collection; containers; waste chute.

STATE OF BOTTOM SEDIMENTS OF THE VORONEZH RESERVOIR IN THE PLACES OF WATER DISCHARGE FROM THE TREATMENT FACILITIES OF THE CITY OF VORONEZH

N. V. Kaverina

Annotation. The author considers the problem of pollution of the Voronezh water reservoir within the Voronezh urban agglomeration, in places of discharge of water from the treatment facilities of enterprises of the left bank. The paper uses the results of quantitative chemical analysis of bottom sediments performed on the basis of the ecological and analytical laboratory of the Faculty of Geography, Geoecology and Tourism of Voronezh State University, as well as monitoring data provided by the Federal Service for Supervision of Nature Management and the Department of Natural Resources and Ecology of the Voronezh Region. The database includes the results of monitoring from 2000 till 2021. On the basis of the composition of precipitation the author detected the history of accumulation of pollutants; as well she identified problem areas of the water reservoir in every study period. The author performed a spatio-temporal analysis of the contents of pollutants, calculated the "concentration clarkes" of heavy metals, according to which she created an ordered series for each observation point in ascending order of the attribute value. Based on laboratory studies and results of their statistical processing using correlation analysis the author draws some conclusions concerning the prospects for the Voronezh water reservoir existence and development. The correlations between the "concentration clarkes" and the amount of precipitation for the calendar and hydrological year have been verified. Based on the hydrogen sulfide content in different years, the author concludes about the range of concentration fluctuations and the formation of a cyclic process. She identified the zone of stable degradation of the water reservoir. Its formation occurs above and below the discharge from the municipal sewage treatment plants of the left bank of the city. The results of long-term observations of the quality of bottom sediments indicate a significant anthropogenic load on the part of the Voronezh urban agglomeration. Insufficient water purification, slow flow velocity and turbulence of natural water accelerate the process of natural eutrophication of the water reservoir.

Keywords: water reservoir; bottom sediments; monitoring; treatment facilities; pollutants; total pollution indicator; eutrophication.

ROAD TRANSPORT, AGRICULTURE AND CONSTRUCTION MACHINES

MODELING OF SOME DYNAMIC CHARACTERISTICS OF TECHNOLOGICAL MACHINES OF THE ROAD-BUILDING COMPLEX

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Annotation. We considered some variants of modeling control of mobile technological machines of the construction complex for various tasks in automation of work processes in order to reduce emissions into the atmosphere by reducing fuel consumption. We presented as well possible schemes for reducing harmful vibration effects on the machine operator. Being based on the analysis of dynamic characteristics in the operator form and taking into account the transfer functions, we considered the requirements for the suspension of a technological machine. This increases the protection of the driver from the effects of vibrations during automatic control of work processes. Functional schemes of dynamic systems are given, which allows us to take into account changes in the elastic and damping properties of the processed soil surface.

Keywords: technological machines; automation; dynamic control system.

ECONOMICS AND ORGANIZATION OF CONSTRUCTION

MANAGEMENT OF APARTMENT BUILDINGS IN RUSSIA BEYOND BUDGETING

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Annotation. The article examines the 12 principles of *Beyond Budgeting*, proposed by J. Hope and R. Fraser, and the peculiarities of their application to the management of multi-apartment buildings. The possibility of introducing *Beyond Budgeting* is analyzed not only in management organizations, but also in the direct management of apartment buildings and in creation of a homeowners' association. The results of the implementation of the principles of *Beyond Budgeting* (change in organizational culture) are analyzed according to the McKinsey 7S model. Recommendations for the implementation of *Beyond Budgeting* are given in the framework of the theory of organizational change by M. Beer and N. Noria. The positive experience of implementing principles of *Beyond Budgeting* at OOO Management Company 'Mayak' allows us to recommend *Beyond Budgeting* management to other organizations carrying out entrepreneurial activities in the management of apartment buildings in Russia.

Keywords: housing and communal services; apartment building; management organization; adaptive management; organizational changes; Beyond Budgeting; McKinsey 7S; E and O theories.

ANALYSIS OF FACTORS AFFECTING HOUSING AFFORDABILITY IN RUSSIA

E. E. Timofeeva, Yu. E. Ostryakova

Annotation. Housing affordability is a very multifaceted concept that reflects the socio-economic processes in society, which take into account the expectations of the population and its income. We carried out analysis of the factors determining the pricing policy in the real estate sector. All identified factors are divided into two groups: objective and subjective. The group of objective factors included those ones that depend on the macroeconomic situation, the situation in the real estate market and which cannot be influenced by households. Subjective factors include the ones that depend on the households or can be changed by them. We show that the influence of the identified factors must be considered comprehensively, which is due to their interrelation and disproportionate interdependence. On the example of price monitoring for the city of Ivanovo (Russia), we demonstrate a significant variation in prices in the segment of housing estate, both economy and business class. We give some examples of the analysis of various factors influence on the formation of cost of housing estate in various categories. We offer differentiation of the concepts of *affordable housing estate* and *affordable comfortable housing*. In particular, when calculating the criteria for housing affordability (regardless of the calculation method), the average price for the most economical options for new buildings should be taken into account. As well we offer substantiation of the importance of state participation in the formation of affordable housing estate both by regulating the income of citizens and by introduction of state programs to support citizens in home buying.

Keywords: affordable housing; mortgage; cost of housing; factors of affordability.

FEATURES OF LAND VALUATION IN PROJECT FINANCING USING ESCROW ACCOUNTS

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Annotation. We carried out the analysis of the current situation in the primary residential real estate market as part of the transition to new conditions for financing housing construction. We identified the advantages of introducing project financing, as well as problems limiting its effectiveness on the basis of the identified main trends and areas of application of project financing in Russia in construction, when implementing infrastructure projects and in the activities of development institutions

to attract private investment into the project financing system. We show the principles of constructing a scheme for a construction project, implemented with project financing according to a pre-compiled model, where escrow accounts are used. A method for assessing a land plot for project financing using escrow accounts of the intended use is proposed. To assess the investment value of land, that is the value at which the income from the acquisition of a land plot corresponds to the rate of interest set by the investor, or the value that meets the investor's requirements for the profitability of a particular project, it is recommended to use three cash flows, namely, cash flow from investment activities, financial activities and the flow on equity capital of the project. We analyzed the development of foreign countries in the context of cost formation of land within the city and relevant factors influencing this cost. The advantages of assessing a land plot with project financing using escrow accounts have also been revealed: convenience, guarantees, transparency and support.

Keywords: valuation; land plot; project; financing; escrow accounts; market; investments.