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Slovak University of Technology in Bratislava (Slovakia)

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This monograph presents the approaches and tools for green building, research results of assessment the potential of Europe for preservation and renovation of natural recourses to create the sustainable environment for life and industrial activity. New architectural, structural and technological systems for construction low-rise buildings with using diffrerent materials have been considered and proposed. In the book, the technologies of energy efficient building design and construction are described.

It can be used as Urban Agenda for Regions` Sustainable Development. For researchers, university students, municipal administration, managers of business structures.

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Chapter I

URBAN AGENDA FOR SUSTAINABLE DEVELOPMENT

1.1. CREATION OF HIGH-TECH AGRARIAN CLUSTERS AND SOCIO-ECO-COMPLEXES IS A STRATEGY FOR THE DEVELOPMENT OF UKRAINE

**Nikolaienko Stanislav, Kulikov Petro, Savytskyi Mykola,
Dukat Stanislav, Popov Viktor**

On September 2015 the United Nations gave final approval to the 17 Sustainable Development Goals (SDGs) for the year 2030 [1], which replaced the Millennium Development Goals (MDGs) (2000-2015) [2]. The overarching purpose of the SDGs is to end poverty, protect the planet, and ensure prosperity for all.

The World Economic Forum [3] has singled out 10 key global challenges that require cooperation from the governments, private sector, civil society, science and education sector. The most important ones are the following: agriculture and food security, economic growth and social inclusion, preventing illness and preserving the health of populations.

A major role in addressing these problems are the agricultural and construction sectors of the economy that provide basic human needs (Maslow) [4].
This is especially true for developing countries, which include Ukraine. However at present, the agricultural sector not only provides food, but is one of the largest supplier of waste.

Buildings and communal services is one of the most energy-intensive sectors of the world economy. Homes and buildings in industrialized countries represent to 40% of total energy consumption [5], of solid waste, greenhouse emissions, of the world's current output of raw materials, 12% of drinking water consumption. By 2025 buildings will use more energy than any other category of "consumers" (today, in the United States they represent 72% of energy use).

A new sustainable development paradigm is based on the provisions of the physical, circular, «green» economy. The study of physical economy focused on the analysis of the problem of combining economic efficiency and equity in income distribution [6]. The circular economy is an economy that is producing no waste and pollution [7]. This is contrast to a linear economy which is a «take, make, dispose» model of production. A concept of green economy is usually includes those sectors of the economy, which are oriented on production of renewable forms of natural capital [8].

The promising direction of Ukraine's development is modernization of the agrarian sector, development of rural territories through the use of accumulated millennial traditions and integration of modern technologies for the creation on the basis of existing villages of high-tech socioecomplexes, designed to solve important social problems and preserve the natural potential and cultural traditions of the Ukrainian people.

Development of building ecotechnologies in combination with modern bio-agrotechnologies can provide Ukrainians with affordable quality housing worthy of safe and useful work with green technologies on the ground, in tourism and science; to create a new youth-attractive ideology for restoring cultural heritage, cultivating a healthy lifestyle and contemporary thinking in line with the global trend of sustainable development.

According to the Constitution of Ukraine "Land is the main national wealth ..." (Article 14). This is objectively confirmed by the fact that today the agrarian sector is one of the most important sectors of the Ukrainian economy. In our country, which occupies 0.4% of the Earth's land, about 27% of the world's black soil (“chernozem”) reserves is concentrated. According to its physical, structural, mineralogical, chemical, agrochemical properties, Ukrainian chernozem is considered to be the best in the world. No wonder the Ukrainian nation is considered one of the oldest grain-producing nations. The climatic conditions also contribute to this direction of economic development: relatively mild winters, warm summers, sufficient sunshine in the year, moderate humidity, and sufficient rainfall make practically ideal conditions for the cultivation of all major agricultural crops. Ukraine has long been the breadbasket of Europe and according to experts is able to feed about 500 million inhabitants of the Earth.

The urgent need to preserve the environment and ensure the population of the Earth with high-quality food products leads to the search and application of new, alternative, intensive agricultural models based on the concept of obtaining high-quality crops without compromising the environment through the study and taking into account the processes occurring in nature.

To date, alternative methods of agricultural production include: organic agriculture; bio-intensive mini-farming; biodynamic agriculture; ecological agriculture; agrotechnics using microbiological preparations and preparations based on spores of fungi (EM technologies); balanced agriculture with low resource intensity; precision agriculture; regenerative agriculture; agrotechnics based on worm compost, humic preparations and siderates; agrotechnics using energy information components; other technologies that exclude the use of mineral fertilizers.

The key to the prosperity of mankind is to engage in the great cycle of Nature and wisely support it. Today, the unity of matter, energy, and information for researchers in living systems is becoming increasingly apparent. Awareness of this is the need to understand agriculture as a global space process - the transformation of energy and information flows of the Cosmos, the Sun, and the Earth through plant seeds, soil, environment in the process of photosynthesis into absolute value added. Understanding and conscious application of new economic relations based on natural law equivalent to the exchange, consumer co-operation of free owners-co-owners-producers and fair economic methods creates a new economy - the economy of investing and implementing new ideas and projects, the economy of intensive technological development, welfare and development man, economy of the 3rd millennium.

Ukraine on the level of food security far exceeds the results of all other countries in the world. Ukraine can adequately answer the three main challenges of our century - food production, water supplies, energy sources.

Extremely important for the agrarian sector of the economy is not only the growth of production volumes, but also the development of rural social infrastructure:

housing, roads, kindergartens, schools, medical institutions, shops, processing enterprises, cultural establishments. In a market economy, large agroholdings are not interested in this; therefore, a state program for the development of rural areas is needed.

The village is the center of preservation of national traditions, respect for the family and the connection of generations, which has a decisive influence on the formation of the Ukrainian mentality. Ukraine, first of all, is an agrarian state, its formation was under the influence of the processes that took place in villages. At the present stage, an independent Ukrainian state faces a difficult task of reviving the village.

Thus, modernization of the agrarian sector of the economy on the basis of the development of agrarian and construction technologies is extremely relevant for Ukraine. Modernization of the agrarian sector of Ukraine's economy is possible on the basis of the development of high-tech agrarian socioecomplexes

The main direction of the nearest time it is necessary to consider the sustainable development of rural areas through reconstruction of both existing and creation of new types of individual farms and communities. The organizational form of the creation of new formations can be agrarian and building clusters (ABCs). Cluster is completely self-sufficient that can power and feed itself with closed internal cycle of material and energy flows and the external supply of products and surplus energy to other consumers.

The concept of a non-governmental national project for rational development of the Ukrainian people on the basis of natural agriculture includes, first of all, the construction of high-tech agrarian socio-eco-complexes.

It is developed on the basis of an analysis of trends in the processes of globalization and the role of Ukraine in the global division of labor, on the basis of the principles of balanced (sustainable development), the characteristics of the modern postindustrial information society ("knowledge society"), the formation of a "national idea", the experience of existence on the territory of Ukraine, the farming Trypillya culture, the experience of the existence of the Cossack "winterers" and farms, the modern technologies of natural agriculture, the study of world experience of existence ecological settlements, innovative energy-efficient, building and information technologies.

The term "high-tech agrarian socioecomplex" means the social environment in which people live, work, rest and in which production (on the basis of the use of high agrarian technologies), scientific (aimed at creating innovative projects), the educational activity of a person is safely and harmoniously integrated in the natural environment in a way that supports the free, healthy, comprehensive human development and is responsible for future generations.

The basic principles of the establishment and functioning of agrarian socioecomplexes are: environmentally friendly, high-tech, business and social activity of residents, comprehensive human development.

The principle of environmental friendliness means the use of technology and life of people in the socioecomplex, preserves and does not destroy the natural habitats of flora and fauna, fit into the natural environment, have a beneficial effect on the environment, materials of structures of buildings and structures are environmentally friendly and do not harm human health.

The high technology of socioecomplex is due to the need to ensure resource conservation, energy efficiency, competitive advantages to ensure economic efficiency. This creates an effective symbiosis of classical and advanced technologies in agriculture, construction, communal economy, energy, computer science, communication, education, and others.

With regard to agrarian technology, it's useful to get acquainted with the report of Policy Horizons Canada " MetaScan 3: Emerging Technologies", which deals with technologies that will radically change agriculture.

Automatic sensing systems allow real-time monitoring of land characteristics, afforestation and water masses and will become a significant addition to automated farms. Thanks to telemechanical equipment, mechanical devices, such as tractors, will be able to warn the driver of a breakdown before it happens. Animals will wear devices (collars, clamps, chips, etc.) to track and transmit information about their biometric indicators in real-time. The crop sensors will be able to determine the required amount of organic fertilizers and crop condition.

In the future, scientists will create completely new modifications of agricultural animals and plants for better satisfaction of human needs. Unlike genetically modified, genetically grown foods will be created from scratch. In vitro meat can be translated as artificial meat, meat in a tube or vitro, i.e meat that has never been part of an animal.

Monitoring the use of resources using automation technology will save material resources - seeds, minerals, fertilizers and herbicides. Equipment will be able to pre-calculate the area on which the above resources will be used, and "understand" what productivity in one or another part of the field.

Agricultural robots (Agbot - Agricultural Robots) can be used to improve labor efficiency, which can be used for various purposes: for the automation of agricultural processes such as harvesting or fruit harvesting, plowing, soil care, weeding, planting, irrigation and so on.

Precision farming is based on observing and responding to differences (heterogeneity) within a single plot of land. The latest technologies, such as satellite imagery and special sensors, are used to track these heterogeneities. Exact farming allows you to determine the problem areas of the field and to make fertilizers not throughout the area of the field, but only where it is needed. Precision farming helps farmers increase yields and save resources. Precision agriculture, as well as geolocation weather data and sensors, is a step towards the creation of automated technologies for making robust solutions in agriculture.

Robotic farms are a combination of dozens or hundreds of agricultural robots, as well as thousands of microscopic sensors that can monitor, predict, grow and harvest with minimal human participation.

Closed ecological systems that do not depend on external changes, will be able to process waste in oxygen, food and water. This will help maintain existence within the system.

Synthetic biology means biological programming based on standardized templates. The purpose of the technology is to create (or restore) artificial biological systems that can process information, manage properties, create materials and structures, produce energy, provide nutrition, and maintain and improve human health and the state of the environment.

Vertical agriculture, vertical farms, as a type of urban agriculture, can grow plants or living organisms in special skyscrapers, using greenhouse technology and energy efficient lighting. Benefits: the ability to produce products throughout the year, independence from weather conditions, and reduced transport costs.

All these technologies, no matter how futuristic they look, are being developed today and will be implemented in the next ten years.

The next basic principles of the creation and functioning of agrarian socioecomplexes are the business and social activity of the inhabitants, the comprehensive development of man, which means creating conditions for stimulating entrepreneurship, efficient use of resources and active life positions, human development, both professionally and personally, on the basis of advanced educational technologies.

The scale of the socioecomplex and the optimal number of inhabitants should provide conditions under which all residents know each other, and at the same time everyone is aware that it can affect the development of the socioecomplex. According to available data, the upper limit of this group is approximately 500, and the optimal number is 300 people. Given the average composition of the family 3 - 4 people the optimal number of individual residential buildings in the socioecomplex may be 70-100 units.

Safe integration into the natural environment of the socioecomplex is based on the study and effective use of existing natural mechanisms. This implies that a person is a part of nature and its partner. The next feature is the multiple use of material resources instead of one-time use, which is typical of the consumption society.

In the socioecomplex priority is given to the following areas:

a) energy-saving technologies;

b) the use of renewable energy sources (biomass, hydrogen, biogas, solar energy, wind, etc.);

c) composting of organic wastes, which thus return the land and subsequently are effectively used;

d) ensuring the processing of inorganic wastes, which may be carried out by the socioecomplex to reduce the harmful effects on the environment;

e) use of materials, structures, devices and engineering equipment that has minimal environmental actions at their disposal at the end of the life cycle.

As already noted, the method of organic (natural) agriculture (permaculture) is at the basis of the creation of the biosystem and the management of agriculture in the socioecomplex. The method of natural agriculture is unique in that it is based on the creation of ecosystems in the nature of natural communities. In applying to the socioecomplex this means the creation of a stable, partially closed ecosystem, the biopotential of which will be large enough to ensure, without damage to the system itself, to fully provide the population with food and other organic materials.

When designing socioecomplex, the concept of building ecostructures is used taking into account the stages of their full life cycle (extraction of materials, construction, exploitation, utilization) and the following requirements:

a) conducting mandatory geoecomonitoring for the selection of a favorable territory of construction, where there are no harmful external actions (noise pollution, air pollution, soil pollution, groundwater, geopathogenic zones, etc.);

b) comfort of the dwelling, fulfillment of sanitary norms at affordable prices, both during construction and in subsequent exploitation;

c) reduction of consumption of energy and other resources due to the use of resource and energy-efficient technologies;

d) minimizing the harmful effects on humans and the environment through the use of environmentally friendly renewable organic materials (wood, cane, hemp, straw), local materials (clay, ground concrete) and low-yielding technologies;

e) audit (upon commissioning) and monitoring (during operation) of the technical condition, indicators of comfort, energy efficiency, environmental parameters of the building.

Taking into account that the future of humanity's development in the knowledge society, the socioecomplex together with agrotechnologies develops, first of all, the information economy, in which most of the gross domestic product is provided by the activity of producing, processing, storing and disseminating information and knowledge. Here we come to the forefront of work with the information product: programming, book creation, consulting and training, development and implementation of know-how, etc.

Thanks to the intensive information exchange and new methods of scientific research, model ideas, the socioecomplex themselves will be factors of advancement of science and innovative technologies.

Today, we have developed a number of pilot projects in Ukraine for the rehabilitation of existing and development of new self-sufficient agrarian and building clusters. The aim of these projects is the creation demo facilities for high tech events as a showcase for further distribution, measurement and monitoring of environmental parameters, the built environment and human capacity.

Agrarian and building clusters (ABCs) have not only environmental and financial value, but also social value, by solving the housing problem, reducing of the rural depopulation, contributing the return of city residents into the rural area and creation of jobs, creating a framework of the self-sufficient families and communities, reconnecting and harmonizing people with nature, self-fulfillment and achieving happiness.

REFERENCES

1. https://en.wikipedia.org/wiki/Sustainable_Development_Goals
2. http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20 (July%201).pdf
3. https://en.wikipedia.org/wiki/World_Economic_Forum
4. https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs
5. U. Berardi. Building energy consumption in US, EU, and BRIC countries.- Procedia Engineering 118 (2015) 128 – 136.
6. http://www.eoht.info/page/Physical+economics
7. https://en.wikipedia.org/wiki/Circular_economy
8. https://en.wikipedia.org/wiki/Green_economy
9. http://www.horizons.gc.ca/en/content/metascan-3-emerging-technologies-0

1.2. UKRAINIAN CONSTRUCTION STANDARDS TO APPLY IN SUSTAINABLE BUILDING DESIGN

Babenko Maryna, Savytskyi Mykola, Kotov Mykola

Today the building is considered as a complex system of elements, which is present by **input value** (materials, sources, energy, etc.) asses by **output value** (emission, waste, etc.) and by **outcome one** (quality of people use the building). Each element is taken into account according to the general principles of sustainable development. Every year there are a lot of new normative and standards appear to ensure the implementation of energy efficiency and ecology in daily practice of building engineers. There are numerous of standards which are being under development currently in EU in the international legitimate level and in the world in the commercial level.

For Ukraine adaptation such new standards is the strategic issue in several meaning: to provide energy independence in the building sector (development of energy autonomic, energy effective green buildings) and to approach to the well developed international community of sustainable (responsible) engineering, create attractive investment base.

Complex studying of existing national Ukrainian normative in the field of ensuring energy efficiency in constructions and its comparative analysis will simplify the understanding of gaps between national legitimate and acting in EU one; develop the working basic instrument for engineers to design in sustainable way by existing norms.

The literature study and comparative analyze were used as the base of the present research. All the studied standards in the field of green building were divided in two general groups: normative and voluntary, each of which listed other sub-groups (Fig. 1).

There were defined current Ukrainian standards in the field of energy efficiency and environmental housing design for compliance with European analogues and standards of sustainable. Those European standards that today have no analogues in Ukrainian norms, but which are important in the development of sustainable buildings projects are highlighted as N/A.

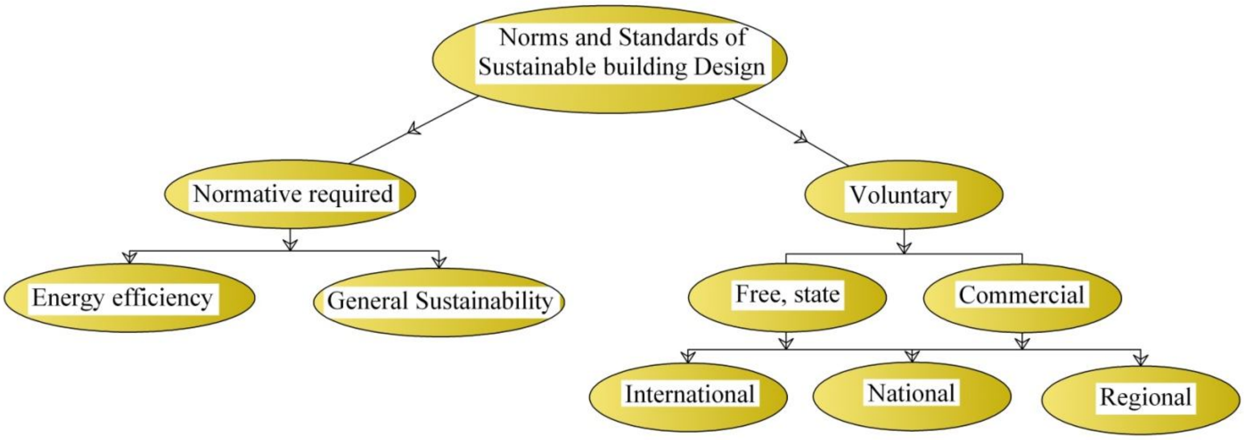

Fig. 1 Hierarchy for effective acting norms analysis

The voluntary standards applying around the world in construction sector were studied. The criteria which are in priority in the context of actual situation in the construction sector of Ukraine were determinated and on their base the assessment of environmental parameters of building objects.

Normative required construction standards in the field of energy efficiency and sustainability requirements Ukraine and EU.

Adopted in 2005, Directive 2005/32 / EC sets requirements for the environmental and energy components of products. In accordance with this Directive, manufacturers of products are required to take measures to reduce energy consumption and other negative environmental impacts throughout the life cycle of products. This approach was called "eco-design"- from resources to utilization within the chain: natural resources - production - transportation - exploitation - utilization. In order to expand the scope of the aforementioned directive in 2009, Directive 2009/125 / EC on eco-design was enacted, which included the inclusion of not only energy-intensive, but also some products that affect energy consumption (eg plumbing). The following stages of the product life cycle are formed: the definition of raw materials and materials, design, production, packaging, transportation, implementation, installation, use, maintenance, utilization. For each stage of the product life cycle, environmental aspects are assessed according to the following parameters set by the Directive: expected costs of raw materials, materials, energy and other resources; Expected emissions into the atmosphere, water or soil; pollution due to physical factors of the environment; the ability to recycle, recycle and dispose of materials and / or energy.

The EU has the most significant experience in the application of methods for technical regulation of energy efficiency [8]. The main types of regulatory legal documents used in the EU are as follows:

- regulations (fully binding and applicable in all Member States);

- directives (binding on Member States in terms of results to be achieved and to be reflected in the national legal framework);

- decisions (required only for the entities to which they are addressed);

- recommendations and conclusions (not binding and are declarative documents);- standards (applied on a voluntary basis, but various measures are taken in the EU to stimulate their application).

To date, the EU has a large number of regulations and directives aimed at implementing energy efficiency. The main instrument for regulating energy efficiency issues in the EU is regulations, directives and standards. In the practice of technical regulation of energy efficiency in the EU there are two main methods - marking energy efficiency and setting requirements for eco-design products (environmentally-oriented design).

In 2010, Ukraine joined the Energy Community Treaty, which required the enactment of the laws, regulations, and administrative provisions necessary to comply with the requirements of the Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of to the use of energy from renewable sources.

In accordance with the decisions of the Energy Community, the following Directives of the European Parliament and the Council on Energy Efficiency are required: Directive 2006/32 / EC on energy end-use efficiency of energy and energy services; Directive 2010/31 / EC on energy efficiency in buildings; Directive 2010/30/ EC on labeling and standard product information, energy consumption and other resources by energy products. In view of the need to ensure the effective implementation of international energy efficiency criteria and the detection of gaps in the national regulatory and technical base, it is necessary to carry out an analysis of existing EU regulatory documents and compare them with existing ones in Ukraine or to establish the absence of such.

Absolutely correct comparison is difficult for a number of reasons, namely:

1. There is no possibility to compare energy efficiency classes, because the main condition though is the same for Ukrainian and European energy efficiency standards, but they are calculated in different ways. Since the results are given in different units of measurement, and take into account different factors [1].

2. European regulatory framework in the field of energy efficiency, with initially higher requirements for the construction site, began to form much earlier than in the Ukrainian SSR and independent Ukraine. In addition, it is comprehensive, taking into account not only the amount of heat loss and the costs associated with providing a comfortable temperature, but also takes into account the amount of carbon dioxide emissions, not only when operating a ready building, but also during extraction, production and transportation of materials, i.e. throughout the life cycle, affecting the principles of the non-circular economy, considering buildings as a complex structure with subsequent processing and full disposal at the end of its life of all without exception Ia structural elements.

3. Ukrainian regulatory documents in the field of energy efficiency have been published and supplemented, with higher requirements for heat loss since the beginning of the 2000th year. However, their number is insufficient, some are superficial, and they do not cover a significant range of parameters that must be taken into account and normalized for the possibility of designing reliable, durable, energy-efficient and eco-friendly housing. As can be seen from Table 1.1, Ukrainian norms can be compared with European norms, at best only partially, and for frequent Ukrainian analogs simply are absent.

Table 1.
Comparative analysis of energy efficiency standards in the EU and Ukraine

Title	Content	Nearest Ukrainian counterpart
Energy performance of building		
Directive EPBD (On Energy Performance of Buildings) - the basis of all EU energy efficiency standards.	The purpose of this directive is to achieve a comprehensive energy efficiency improvement for all EU buildings	Law of Ukraine "On Energy Efficiency of Buildings"
EN 15217 Energy performance of buildings - Methods for expressing energy performance and for energy certification of buildings	This standard is devoted to methods for determining the energy performance of buildings, as well as drawing up a certificate of energy efficiency.	DBN V.2.6-31:2016 (partially)
EN 15603 Energy performance of buildings. Overall energy use and definition of energy ratings	The purpose of the standard is: a) compare the results of other standards that calculate the use of energy for one or another service within the building; b) take into account the energy produced in the building, a certain part of which may be transferred for use elsewhere; c) provide a summary of the energy use of the building in tabular form; d) provide energy assessment based on primary energy, carbon dioxide emissions or other parameters specified by the national energy policy; (e) Establish general principles for calculating primary energy factors and carbon emission factors. This standard defines energy services that need to be taken into account for rating energy performance for projected and existing buildings. f) method for calculating the standard calculated energy rating (passport), standard energy usage, which does not depend on the behavior of residents, actual weather and other actual (surrounding or internal) conditions; g) method for estimating the energy rating (passport) on the basis of supplied and used energy; h) methodology for increasing the reliability of the calculation model of a building compared with actual energy use; i) a method for assessing the energy efficiency of possible improvements.	DBN B.2.6-31:2016 (partially) DSTU B V.2.2-39:2016 (partially) DSTU B V.2.2-21:2008 (partially)
BS EN ISO 13790 Energy performance of buildings. Calculation of energy use for space heating and cooling	These norms include the calculation: a) heat transfer when ventilation of the building area when heated or cooled to a constant internal temperature; b) the contribution of internal and solar heat to the	DBN V.2.6-31:2016 (partially); DSTU B V.2.2-

	thermal balance of the building; c) annual energy requirements for heating and cooling, as well as for maintaining the set room temperature; d) annual energy consumption for heating and cooling of the building using the relevant system standards specified in this standard.	21:2008 (partially); DSTU B. A. .2.2-12:2015
EN 15316-1 Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies. General and Energy performance expression, Module M3-1, M3-4, M3-9, M8-1, M8-4	These norms include calculation: heat, mathematical calculations, efficiency, energy consumption, thermal power, thermal protection systems, heating equipment, buildings, systems of spatial heating, heat transfer, heat loss, hot water supply systems.	N/A
EN 15316-2 Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies. Space emission systems (heating and cooling), Module M3-5, M4-5.	These norms include calculation: heat losses, hot water supply systems, energy saving, thermal protection systems, heating equipment, heat power, buildings, heat exchangers, heaters.	N/A
EN 15243 Ventilation for buildings. Calculation of room temperatures and of load and energy for buildings with room conditioning systems.	These standards include: a) Determination of the calculation procedure, calculation methods for temperature determination, reasonable loads and energy requirements for the premises to be used in the design process; b) Description of calculation methods for determining the hidden cooling and heat load for building heating, cooling, humidification, drainage and loading on these systems; c) Determination of the general approach for calculating the total energy efficiency of buildings with air conditioning systems; d) Determination of one or more simplified methods for calculating the energy needs of the system for specific types of systems based on demand and energy consumption of a building derived from EN ISO 13790 and determining their scope.	N/A
EN 15316-3 Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies. Space distribution systems (DHW, heating	These standards include: heat losses, heating equipment, spatial heating systems, thermal calculation of buildings, thermal efficiency, energy consumption, mathematical calculations, central heating, heat exchange, thermal protection systems, hot water supply systems, efficiency, buildings.	DBN V.2.6-31:2016 (partially)

and cooling), Module M3-6, M4-6, M8-6.		
EN 15265 Energy performance of buildings. Calculation of energy needs for space heating and cooling using dynamic methods. General criteria and validation procedures.	These standards include: a) Evaluate the energy characteristics of each room in the house; b) Supply of energy data to be used as an interface for analyzing system performance (heating, cooling, ventilation, lighting, domestic hot water, etc.). The procedure is used to check the energy requirements for heating and cooling of premises based on the model of transitional sound thermal balance taking into account: - external thermal balance of the surface; - conductivity through the shell of the building; - thermal power of external and internal structures; - internal heat balance; - air heat balance; - methods for determining the thermal balance.	DSTU B V.2.6-37: 2008 (partially) DSTU B V.2.6-101: 2010 (partially) DSTU B V.2.6-189: 2013 (partially) DSTU B V.2.2-21: 2008 (partially)
EN 15193 Energy performance of buildings. Energy requirements for lighting.	These standards include: electrical measurements, performance, lighting systems, design, electrical power systems, energy consumption, lighting equipment, mathematical calculations, fixtures, power measurement (electric), electric lamps, buildings, electricity consumption, energy saving, indoor lighting.	DSTU B V.2.2-21: 2008 (partially)
EN 15241 Ventilation for buildings. Calculation methods for energy losses due to ventilation and infiltration in buildings.	This standard describes a method for calculating the energy impact of ventilation systems (including ventilation) in buildings, which will be used to calculate the thermal and cooling load. His goal is to determine how to calculate the characteristics (temperature, humidity) of air entering the building, and the corresponding energy required for its processing, as well as the required amount of electrical energy for the auxiliary devices.	DSTU B A.2.2-12: 2015 (partially) DSTU B V.2.6-37: 2008 (partially)
EN 15232 Energy performance of buildings. Impact of Building Automation, Controls and Building Management.	These standards include: control systems, efficiency, lighting systems, heat engineering, ventilation, thermal protection systems, air conditioning systems, automatic control systems, buildings, mathematical calculations, spatial heating systems, energy saving, productivity, energy consumption, heat calculation of buildings.	N/A
EN ISO 6946 Building components and building elements. Thermal resistance and thermal transmittance. Calculation methods.	These norms include: heat transfer, thermal conductivity, mathematical calculations, thermal balance of buildings, buildings, thermal insulation, thermal stability, details of building systems.	DSTU B V.2.6-100: 2010 (partially) DSTU B V.2.6-101: 2010 DSTU B V.2.6-189: 2013
EN ISO 13370 Thermal performance of buildings. Heat transfer via the ground. Calculation methods.	These norms include: physical properties of soils, temperature, soil, equation, floor, floor boards, formulas (maths), thermal insulation, cellars, thermal properties of materials, heat measurements, thermal behavior of structures, thermal resistance, heated floors, heat	N/A

	transfer , climate, hanging floors, thickness, ventilation, heat transfer coefficient, refrigerating chambers, groundwater, dimensions, mathematical calculations, thermal conductivity, thermal bridges.	
EN ISO 10077-1 Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. General.	These standards include: double-glazed windows, doors, thermal design of buildings, mathematical calculations, window frames, windows, blinds (buildings), details of building structures, thermal insulation, glazing, doors, window glass, thermal conductivity.	DSTU B.2.6-XX: 200X (partially) DSTU B V.2.7-107: 2008 (partially)
EN 13947 Thermal performance of curtain walling. Calculation of thermal transmittance.	These standards include: buildings, curtains, lining (buildings), building components, thermal conductivity, glazing, glass, heat transfer, mathematical calculations, thermal bridges, thermal calculation of buildings, thermal insulation.	N/A
ISO 10077-2 Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. Numerical method for frames.	These standards include: frame for slots, door frames, glazing, windows, mathematical calculations, roller shutters, specific heat conductivity, parts of building systems, doors, door block (door with door box), thermal measurements, window frame, heat transfer, thermal conductivity .	N/A
EN ISO 14683 Thermal bridges in building construction. Linear thermal transmittance. Simplified methods and default values.	These standards include: classification of systems, constraints, heat transfer, parts of building structures, thermal conductivity, buildings, heat transfer, mathematical calculations, heat calculation of buildings, definitions, thermal bridges, linearity, construction work.	DSTU B EN 13187: 2011 (partially)
EN ISO 10456 Building materials and products. Hygrothermal properties. Tabulated design values and procedures for determining declared and design thermal values.	These standards include: building materials, buildings, thermal calculation of buildings, thermal properties of materials, specific thermal conductivity, heat resistance, homogeneity, change, temperature, material aging, humidity, thickness, test conditions, calculations, statistical methods of analysis.	N/A
EN 15242 Ventilation for buildings. Calculation methods for the determination of air flow rates in buildings including infiltration .	These standards include: air flow, ventilation equipment, buildings, air flow measurements, mathematical calculations, heat shrinkage systems, ventilation, air conditioning systems, mechanical ventilation, air, and productivity.	DBN V.2.6-31: 2006 (partially) DSTU B V.2.2-19: 2007 (partially)
EN 13779 Ventilation for non-residential buildings. Performance requirements for ventilation and room-conditioning systems.	These standards include: heat shrinkage systems, air, system classification, thermal design of the building, thermal comfort, quality, air conditioning systems, ventilation, air conditioning equipment, ventilation equipment, efficiency (productivity), buildings, operating conditions, energy consumption .	N/A
EN 15251 Indoor	This standard specifies indoor environmental conditions	N/A

environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.	in buildings that affect the energy efficiency of buildings: - How to set the internal input parameters of the environment to calculate building design and energy efficiency. - Methods for the long-term assessment of the internal environment, obtained as a result of calculations or measurements. - measurement criteria that can be used if a compliance check is required. - determines the parameters that will be used to monitor and display the internal environment in existing buildings. This standard is applicable mainly to non-industrial buildings, where the criteria for the internal environment are established by the person and the production process does not significantly affect the internal environment. The standard can thus be applied to the following types of buildings: single-family houses, apartment buildings, offices, educational institutions, hospitals, hotels and restaurants. The standard specifies how to use different categories of criteria for the internal environment. But their use is not unconditional and depends on national rules or specifications of individual projects. The recommended criteria in this standard may also be used in national calculation methods that may differ from the methods described herein. The standard does not design design methods, but gives the water parameters for designing buildings, heating, cooling, ventilation and lighting. The standard does not include criteria for local discomfort factors such as sediment, asymmetry of the radiant temperature, vertical air temperature difference and surface temperature	
EN ISO 15927-5+A1 Hygrothermal performance of buildings. Calculation and presentation of climatic data. Data for design heat load for space heating.	These standards include: maintenance of buildings, equipment of thermal systems, systems of spatial heating, climatic loading, humidity, windows, speed, methodology of determination and measurement, design of heat communications, thermal protection, heat calculation of a building.	N/A
EN ISO 7345 Thermal insulation. Physical quantities and definitions.	These norms include: units of measurement, definitions, symbols, terminology, thermal properties of materials, thermal insulation, thermal conductivity.	ДБН В.2.6-31:2016 ДСТУ Б В.2.6-34:2008
EN ISO 9288 Thermal insulation. Heat transfer by radiation. Physical quantities and definitions.	These norms include: units of measurement, definitions, symbols, terminology, thermal properties of materials, thermal insulation, thermal conductivity.	N/A

EN 12792 Ventilation for buildings. Symbols, terminology and graphical symbols	These standards include: ventilation, terminology, symbols, graphic symbols, buildings, air conditioning systems, air conditioning equipment, ventilation equipment.	N/A
EN 15378 Heating systems in buildings. Inspection of boilers and heating systems.	These standards specify the procedures and additional measurement methods that will be used to check and assess the energy performance of boilers and heating systems.	N/A
EN 15240 Ventilation for buildings. Energy performance of buildings. Guidelines for inspection of air-conditioning systems.	These standards include: thermal protection systems, ventilation equipment, maintenance, energy consumption, air conditioning systems, cooling, air conditioning equipment, inspection, buildings, heating, productivity, ventilation.	N/A
EN 15239 Ventilation for buildings. Energy performance of buildings. Guidelines for inspection of ventilation systems.	These standards include: ventilation, ventilation equipment, ventilation ducts, air, energy saving, power consumption, mechanical ventilation, buildings, control systems.	N/A
Sustainability of building		
ISO 15392:2008 Sustainability in building construction -- General principles	This standard identifies and establishes general principles for sustainability in building construction. It is based on the concept of sustainable development as it applies to the life cycle of buildings and other construction works, from their inception to the end of life.	N/A
ISO 21929-1:2011 Sustainability in building construction -- Sustainability indicators -- Part 1: Framework for the development of indicators and a core set of indicators for buildings	This standard establishes a core set of indicators to take into account in the use and development of sustainability indicators for assessing the sustainability performance of new or existing buildings, related to their design, construction, operation, maintenance, refurbishment and end of life. Together, the core set of indicators provides measures to express the contribution of a building(s) to sustainability and sustainable development. These indicators represent aspects of buildings that impact on areas of protection related to sustainability and sustainable development.	N/A
ISO/TS 21929-2:2015 Sustainability in building construction -- Sustainability indicators -- Part 2: Framework for the development of indicators for civil engineering works	This standard establishes a list of aspects and impacts which should be taken as the basis for the development of sustainability indicators for assessing the sustainability performance of new or existing civil engineering works, related to their design, construction, operation, maintenance, refurbishment and end-of-life. Together, the indicators developed from this list of aspects and impacts provide measures to express the contribution of a civil engineering works to sustainability and sustainable development. The developed indicators should represent aspects of civil engineering works that impact on issues of concern related to sustainability and sustainable development.	N/A

ISO 16745-1:2017 Sustainability in buildings and civil engineering works -- Carbon metric of an existing building during use stage -- Part 1: Calculation, reporting and communication; Part 2: Verification	This standard provides requirements for determining and reporting a carbon metric of an existing building, associated with the operation of the building. It sets out methods for the calculation, reporting and communication of a set of carbon metrics for GHG emissions arising from the measured energy use during the operation of an existing building, the measured user-related energy use, and other relevant GHG emissions and removals. These carbon metrics are separated into three measures designated CM1, CM2, and CM3	N/A
ISO 21930:2017 Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services	This standard provides the principles, specifications and requirements to develop an environmental product declaration (EPD) for construction products and services, construction elements and integrated technical systems used in any type of construction works.	N/A

Voluntary standards of environmental assessment of buildings according to the sustainability principles. The principles of "green" construction presuppose the application of a certification system developed on the basis of the concept of sustainable development, taking into account national particularities. For most of the countries of the post-Soviet space, support for the global trend in the development of the construction industry in accordance with "green" standards is becoming more urgent due to the need to address such actual problems as high dependence on fuel and energy resources, irrational use of land resources, shortage of affordable quality housing, low energy efficiency of the existing housing stock.

Among the problems and peculiarities of certification of construction objects for compliance with the standards of sustainable development were scientists such as Granev V.V. [2], Zhurba A.O. [3], Kozharinov A.V. [4], Matrosov Yu. A. [5], Naumov A.L. [6], Primak L.V. [7], Sukhinina E.A. [8], Tabunshchikov Yu.A. [2], Rob Watson [8], etc. In different countries of the world Eco-certification has become so popular that environmental standards are considered mandatory for many types of buildings.

At the same time, in Ukraine, construction that meets the standards of sustainable development has been extended so far only at the level of individual developers. Despite the creation of the Council for Green Building and the development of a number of government programs aimed at improving energy efficiency in the housing and communal sector, Ukraine does not have a national system for the environmental certification of construction sites, and the development and implementation of such standards in the country have not been received necessary dynamics. As a result, the principles of "sustainable development" and "green building" have not been integrated into the national construction practice for now.

From the perspective of a modern understanding of sustainable development, environmental requirements should be met by all the components of the construction site, including the building, territory and the consequences of human impact on the environment.

The ecological characteristics of the building can be assessed by the criteria of "green" standards designed to ensure the transition from traditional design and construction to a balanced (sustainable, "clean"), which implies the following principles: safety and favorable healthy conditions for human life, limiting the negative impact on the environment, consideration of the interests of future generations.

On the one hand, the variety of systems for the environmental certification of construction sites is justified by the differences in the conditions under which they are implemented - geographic location, climatic conditions, the level of development of construction technologies, the market of materials and services, etc. However, rating systems with a different set of criteria create certain difficulties for stakeholders, including investors who buy buildings in different countries.

All existing systems of environmental certification of the building, taking into account the number of certified facilities and their geography, can be conditionally divided into global distribution systems and the systems of national importance.

The group of global rating systems include the LEED standard (USA) and the BREEAM standard (UK), which have the following features:

• these standards were adopted as national standards in many countries or formed the basis of national rating systems;

• according to these standards, more objects are certified than other rating systems;

• these standards have become widespread and popular.

The national rating system includes all national standards, for example, German standard DGNB, French HQE, Danish EcoProfile, Japanese CASBEE, Canadian GBI, Russian Green Standards.

In recent years, based on the standards of sustainable development in construction, they have started to create software packages for the assessment of the environmental parameters of the project (BEES - Building for Environmental and Economic Sustainability).

Voluntary assessment of buildings according to the sustainability standards in Ukraine. In Ukraine, at the state level, numerous laws have been adopted and draft laws have been drafted aimed at energy saving in construction. However, up to now, there has not been developed a national voluntary system for assessing buildings in accordance with the standards of sustainable development, taking into account the life cycle - from the project of the construction site to the utilization of building materials.

The "green" standards are based on the Life Cycle Assessment (LCA) method, which includes the following stages: extraction of raw materials, natural materials, processing of materials, production of goods, transportation and distribution, use, maintenance, processing, reuse and disposal waste.

Based on the analysis of foreign experience of the LCA method, the Ukrainian system of voluntary environmental certification of construction objects is proposed, which is harmonized with the world standards of sustainable development. Its tasks are:

• Minimization of the negative impact of the property on the environment;

• minimization of environmental pollution by real estate objects - both during construction and operation;

• rational use of natural resources necessary for the construction and operation of real estate;

• Introduction of advanced energy-efficient technologies into the practice of construction and operation of buildings and structures;

• Promotion and promotion of the development of green building in Ukraine;

• Assistance to buyers in the competent choice of real estate objects that do not have a negative impact on the environment.

The following construction sites are subject to certification:

• land plots - a part of the earth's surface (including the soil layer), the boundaries of which are described and fixed in the established order;

• new buildings and structures - capital construction facilities that have load-bearing and enclosing or combined structures forming a closed volume;

• objects of construction in progress - a building or structure for which documents on the commissioning of the facility have not been issued in accordance with the established procedure;

• operated buildings and structures - capital construction facilities in operation;

• social complexes and settlements - an administrative-territorial unit, united by one territory, infrastructure, social orientation;

• internal premises - objects that are part of buildings and structures.

Formation of environmental requirements for construction sites is the rational use of natural resources, minimizing the negative impact of economic activities on the environment, providing favorable conditions for human life and its self-realization.

In existing systems, one of the priority criteria is energy efficiency, which is mainly achieved and evaluated through the use of high-tech energy-saving equipment, which increases the cost of initial investment in construction. In the conditions of Ukraine, the use of such equipment is difficult because of its high cost.

Since the indicator of the energy efficiency class is one of the most important criteria for compliance with the standards of sustainable development, it was suggested that the developed system assess it with indicators of the effective use of local renewable materials of organic origin with high thermal characteristics and the use of rational architectural and constructive solutions. The energy efficiency class is assessed in accordance with the current Ukrainian standards, whose requirements and method of classification are generally comparable with world standards.

In the proposed system of certification of construction objects, the criteria for sustainable development are determined by the combination of the following indicators: innovative management, site selection, efficient use of natural resources, integration architecture, materials and structures, organization of internal space, operational waste, energy efficiency, economic efficiency and socio-cultural organization.

Innovative management is assessed both at the design stage, and during the implementation of the project, operation and disposal of the construction site. At the design stage, the thermophysical and energy characteristics of the facility, the environmental friendliness of materials, and the optimization of the economic performance of the facility, taking into account the life cycle, are taken into account. For the analysis of these indicators, the project documentation and data received from the developer are studied.

At the stage of the construction project, the following parameters are taken into account: construction of a building site in accordance with environmental requirements for the construction process, minimization of waste during construction work (secondary processing or use of waste); informing citizens about the main indicators of the property, carrying out measures to protect and restore the environment in the process of construction (conservation of the soil layer, recycled water supply, dust suppression, regulation current storm water collection in a single place, wastewater treatment, protection of stem and root system of trees and shrubs, portion reduction with fertile soil).

To assess the environmental impact of the facility during its operation, visual monitoring is used, which includes the analysis of a certain set of indicators, including the use of environmentally friendly fertilizers for gardening, cleaning products, anti-icing agents, the refusal to use mercury-containing lamps, the availability of environmental certificates for engineering equipment object. In addition, at all stages of the building's life cycle, qualified environmental monitoring is carried out, which allows to increase the environmental performance of the building due to timely professional analysis and adjustment.

When **choosing the site** of the construction, the environmental quality is assessed, including the degree of pollution of soil, air, water sources, the effects of electromagnetic radiation, the risks of man-caused impacts and hazardous natural phenomena, the degree of planting of the territory, insolation of the adjacent territory, the protection of the territory from noise, vibration , infrasound, other indicators in accordance with current standards and norms of Ukraine. It also assesses the possible impact of urban development on the existing ecosystem - indicators of the effective use of natural resources and the integration architecture.

Analysis of the **efficiency of the use of natural resources** in such parameters as the reduction of the water consumption per person per year in relation to the standard, the separation of water supply into technological and drinking water, the availability of wastewater reuse systems for toilets and urinals, the collection of rainwater, their purification and use in system of technological water supply, collection of rain water for irrigation of the adjacent territory, accounting of water consumption at the end user, availability of water-saving drain tanks, shower grids, mix Lei, the use of secondary and renewable energy. The given criterion allows to estimate all systems of the building object aimed at energy saving and rational use of available natural resources on the site.

The level of **architecture integration** is evaluated expertly, including the analysis of the quality indicators of the architectural appearance of the facility, its correspondence to the surrounding buildings, functional purpose, originality, architectural perfection, aesthetics. In addition, at the design stage, an assessment should be made of the optimality of the chosen architectural form of the object and its orientation, which are designed to provide the best energy performance, comfort of space-planning solutions (overall indoor indices), natural lighting possibilities, planting of greenery ("winter garden" , vegetative roof, elements of vertical gardening).

The general level of environmental friendliness of the facility is fundamentally affected by the use of **building materials** of natural origin, especially those that are certified as ecological. The quality of materials is assessed for compliance with one of the main criteria of sustainable development - waste minimization and the possibility of their complete reutilization.

Particular attention in assessing the ecological compatibility of the building is paid to the indicators of the organization of the **internal space**. Including air-thermal comfort can be controlled due to the planned measures to optimize the microclimate parameters - temperature, humidity, air exchange, air speed. No less important is light comfort, which is estimated by the degree of compliance with the standards for illumination, the presence of automatic control of artificial lighting or complex LED lighting. Special measures to reduce noise ensure the organization of acoustic comfort in the room, which is especially important in urban development and in the design of apartment buildings and public buildings. Olfactory comfort should be provided both by ventilation systems and by the use of non-toxic materials without sharp odors. An important indicator of the environmental security of a room for a person is the security of the premises from the accumulation of radon.

The next criterion for assessing the environmental friendliness of the facility is the level of **operational waste** - the quality of the organization of collection / disposal of waste and sanitary protection of the facility. It should be noted that to date, the organization of the primary sorting of waste, which is specified in government regulations, has not yet been integrated into the practice of public services for the residential sector. The proposed project provides an indicator of the level of utilization of operational waste, which significantly enhances the environmental friendliness of the facility. The quality of sanitary protection is ensured by the tightness of the garbage chutes and compartments with autonomous mechanical ventilation, the presence of an automated system of antibacterial treatment and an automated system of protection against the rodents and insects of garbage chutes, pantries, cellars, etc.

In the energy and economic realities of Ukraine, one of the key indicators of the environmental friendliness of the facility should be to ensure the **energy efficiency** of construction projects. Energy efficiency is understood as the rational use of energy resources, i.e. use the minimum possible amount of energy to provide the same level of energy supply to buildings or technological processes. The criterion proposes to estimate the cost of heat energy for heating and ventilation in accordance with the energy efficiency class in accordance with current standards; Expenses of thermal energy for hot water supply; electricity costs for lighting, engineering support systems, air conditioning systems, application of LED lighting sources, installation of electrical equipment with a high energy consumption class with the appropriate marking. The presence of a centralized control system of the facility with the possibilities of zonal regulation of the local engineering support system allows monitoring energy efficiency indicators, which improves the overall environmental performance of the facility.

An important indicator of the environmental friendliness of the facility is its **economic efficiency**. This indicator is estimated by the ratio of the investment value of the object to the cost of a similar facility that meets the minimum established requirements, and the ratio of the average annual cost of operating the facility to similar costs for a traditional analogue facility.

The **socio-cultural organization** is assessed from the point of view of the reach of the objects of the social and domestic infrastructure necessary for the normal provision of vital functions for people (health care institutions, trade points, passenger transport, banking and postal services, catering, household and communal services, etc.). Particular attention in assessing this criterion should be given to guarantees of accessibility of services for the low-mobility population groups. Estimation of the property's compliance with environmental requirements is carried out by direct comparison of project indicators (or a finished building) with existing standards and standards.

According to the proposed methodology, each score indicator is put a score, which is then summed according to the criterion and by group of criteria. The resulting amount is multiplied by 100% and is divided into the highest possible total score. As a result, the estimated score for the object is calculated.

As a result of certification one of the four types of certificates can be assigned, provided all the necessary requirements have been fulfilled and the total points obtained from the maximum possible score have been achieved (see Table 2).

Table 2.

Proposed certificates for compliance with the level of environmental friendliness of construction sites

Certificate	Somme of points, %
Certified for sustainability requirements	40 – 49
Silver	50 – 59
Gold	60 – 80
Platine	More 80

Conclusions:

1. An analytical review of more than 25 current Ukrainian standards in the field of energy efficiency and environmental housing design for compliance with European analogues and standards of sustainable development has been carried out. Those European standards that today have no analogues in Ukrainian norms, but are important in the development of sustainable buildings projects are highlighted.

2. Based on foreign experience and in accordance with Ukrainian national norms, a system for assessing the environmental performance of construction sites was proposed and registered as the corporative standard at SHEI “Prydneprovska State Academy of Civil Engineering and Architecture”.

REFERENCES

1. Enterprise standard. Conformity assessment. ES SHEI PSACEA 01.01:2014 "Environmental requirements for real estate" - 30 pp.
2. Tabunshchikov Yu. A. Rating system of building quality assessment in Russia / Yu. A. Tabunshchikov, V.V. Granev, A.L. Naumov [Electronic resource]. - Access mode: http://www.abok.ru/for_spec/articles.php?nid=4690 (Date of circulation: 07.11.2014).
3. Zhurba A.O. Ecological certification of buildings and prospects of its application in Russia / A.O. Zhurba // Industrial and civil construction. - 2009. - No. 12. - P. 42-44.
4. Kozharinov A. V. Implementation of "green" construction and resource-saving technologies as factors of transition to sustainable development / A. V. Kozharinov [Electronic resource]. - Access mode: http://www.ecolog46.ru/files/20130307-seminar-zelenoe-stroitelstvo/prezentacija.pdf (Date of access: 27.10.2014).
5. Matrosov Yu. A. Legislation and standardization of the European Union on energy efficiency of buildings / Yu. A. Matrosov // ABOK. - 2003. - No. 8.
6. Primak LV Construction on the "Green Standards" - now in Russia [Electronic resource]. - Access mode: http://ipktek.ru/templates/new_style_1/images/prez_primak/1.pdf (Date of circulation: 13.09.2014).
7. Sukhinina E.A. On environmental standards in architectural and urban planning / E.A. Sukhinina [Electronic resource]. - Access mode: http://cyberleninka.ru/article/n/ob-ekologicheskih-normativah-v-arhitekturno-gradostroitelnom-proektirovanii (Date of access: 11.10.2014).
8. Rob Watson, Green Building Market and Impact Report, 2010.
9. Enterprise standard. Conformity assessment. ES SHEI PSACEA 01.01:2014 "Environmental requirements for real estate" – 32 c.
10. Estimation of environmental parameters of construction objects / M.V. Savytskyi, Yu.B. Benderskyi, M.M. Babenko // Collection of scientific works [Poltava National Technical University. Y. Kondratyuk]. Wed: Industry Engineering, Construction - 2014 - C.144-149
11. Savytskyi, M. V., Bondarenko, O. I., Babenko, M. M. and Benderskyi, Yu.B., 2015. Options of sustainable development of region’s territory. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 4, pp. 157–161.11. Savytskyi, M. V., Bondarenko, O. I., Babenko, M. M. and Benderskyi, Yu.B., 2015. Options of sustainable development of region’s territory. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 4, pp. 157–161.

1.3. REGIONAL PECULIARITIES OF RURAL TOURISM DEVELOPMENT IN UKRAINE (USING AN EXAMPLE OF DNIPROPETROVSK REGION)

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Nowadays, the regional recreational subsystems in different regions of Ukraine are developing unevenly due to both the general state of infrastructure development in the regions, and the various potential recreational resources in the provinces [1].

The main problems of recreational subsystems functioning practically in all regions of Ukraine are insufficient financing of recreational facilities, inadequate level of development of tourist and health resort infrastructure, depreciation of basic recreational institution facilities, non-comformity of service quality with modern requirements etc. The above-mentioned factors definitely cannot fail to affect the decline of tourist flows. At the same time, in areas with a rich recreational potential, the existing network of recreational and tourist establishments is developing, the quality of recreational service is improving, the infrastructure accompanying the tourist and recreational sector is growing quite rapidly. On these territories, the development of the recreational and tourist industry is a priority for social and economic development of the region. In some areas with significant natural recreational resources, but insufficient level of social and economic development as well as infrastructure, the main attention should be paid to the development of the transport network and accommodation facilities to realise the full potential of natural recreational resources.

For many regions of Ukraine the prospect of developing the recreation industry consists in creating competitive tourism products, developing domestic tourism that means elaboration of new tourist routes, development of rural tourism, which is now gaining popularity, especially among city residents.

Rural tourism, called in practice green tourism or rural green tourism, according to N.E. Kudla, offers direct relations with the rural community, usage of the rural assets, its surrounding area and existing buildings with maximum preservation of the natural environment. In the development process of rural tourism, more and more new terms reflecting popular tourism directions - alternative, agricultural, and ecological tourism appear [5]. There are other definitions of rural tourism, which, in fact, do not contradict each other, but complement and reveal the multifaceted nature of this problem. I.M. Voloshyn believes that rural tourism includes (for travel purposes) such forms of tourism like agro-tourism, ethnographic tourism, farm tourism, eco, green, and holiday tourism [2]. According to the definition by M.A. Latynin, rural tourism is a type of recreation and tourism, concentrated in rural areas and focused on the development of tourist routes, recreational areas, agricultural and folk museums, as well as tourist service centers with instructors and guides. At the same time, agro-tourism is a form of entertainment concentrated in rural areas, providing for the use of agriculture (farming) for the purpose of recreation, education or active involvement of traditional management forms [3].

Research on rural tourism has been most actively conducted in such areas as administration, legal regulation, history, sociology, economics and geography, management and marketing, particularly in the works of N.M. Voloshyn, N.A. Gerasimchuk, N.E. Kudla, M.A. Latynin, O.I. Lukomtseva etc. Scientific research indicates that rural tourism can provide economic and demographic stability in rural areas and solve their social and economic problems. It also has a positive impact on revival, preservation and development of local folk customs, crafts, and monuments of historical and cultural heritage.

The issues of urban planning and architecture as well as spatial arrangement of rural tourism regarding characteristics of various regions in Ukraine are not studied sufficiently or have not been considered at all.

The market of rural tourism in our country is in its infancy. There is a different degree of activity in the development of rural tourism in the regions. The number of farms working in this market is insignificant and they are concentrated in areas of Ukrainian Carpathian mountains, Slobozhanshchyna, Polissia, and Podillia which have social and economic prerequisites for this. These regions have a significant potential of recreational resources: the Carpathians (34% of total resources) and Polissia (21%). The most active rural tourism is developing in Rivne region (90 farmsteads), in Lviv region (about 500 private estates are engaged in rural tourism), in Poltava region (100 estates of green tourism), and in Khmelnytsky region (64 farmsteads). At the same time, most regions of Ukraine are characterised by a low level of rural tourism development, insufficient spreading of information on tourist and recreational opportunities in the regions. For example, in Dnipropetrovsk region (potential of recreational resources account for 3.5%) there are only 14 rural green tourism estates [1, 3, 8].

The Union for Promotion Rural Green Tourism Development in Ukraine indicates the following weak points in the development of rural tourism in Ukraine: an unfavorable legal and economic environment for the activity of rural population; experience of neighboring countries is not used sufficiently; inconsistency in actions of central executive authorities in the sphere of tourism and agriculturalpolicy; biases in understanding the essence of rural tourism; lack of attractive credit resources for rural population and favourable conditions for investment; at the all-Ukrainian level there is no advertising of rural tourism; problems in obtaining guaranteed and quality services; insufficient number of high-quality accommodation facilities in the center and in the east of the country; the complexity of access to information about unused tourist opportunities of villages; absence of training centers for both managers and rural population [7].

An important factor in the development of rural tourism is forming a regulatory and legislative framework for this type of recreational activities. The current Law of Ukraine on Public Associations - 2012, the Law of Ukraine on Private Farmland - 2003, the Law of Ukraine on Tourism - 1995 (revision of 2015), the Draft Law on Rural Green Tourism – 2003, as well as the Bill on Agricultural Tourism and Related Activity determine a legal, organizational, economic and social basis of tourism in general and rural tourism in particular, define terms and concepts, organisational forms and types of agricultural tourism [13]. However, the Union for Promotion Rural Green Tourism Development in Ukraine (founded in 1996, a member of the European Federation of Farmer and Rural Tourism Eurogites from Ukraine since 2005) critically evaluates the proposed bill on agricultural tourism and related activity, since it does not provide for cooperation with the tourism department and tourism subjects. Besides, they note that the state policy on rural tourism as a whole and its promising form, agricultural tourism, are not defined [7].

The world practice shows that rural tourism is an innovative form of agribusiness which can ensure sustainable development of the agricultural sector and the national economy. According to sociological research, 35% of urban population in Europe prefer outdoor recreation, mainly in rural areas. The development of rural tourism not only helps preserve natural territories and provides jobs to local population, but also contributes to filling budgets of countries and regions [6]. The results of the all-Ukrainian public opinion poll concerning holiday plans of Ukrainian population conducted by Kiev International Institute of Sociology (KIIS) for the period from 2011 to 2014 showed that 11.7% of Ukrainians prefer having rest in rural areas [9].

Development of rural tourism in the regions of Ukraine is largely facilitated by European experience [2, 3, 4, 5]. The history of rural tourism development in Western Europe dates back to the 60s and 70s of the last century. Geographically, this phenomenon was concentrated mainly in agricultural areas of France, Italy, and Germany. The main objective of this type of tourism was preservation of rural settlements through revival of crafts and enhancement of entrepreneurial activity. There were several national European models of rural tourism organization: British, French, German, Italian, Czech, Spanish, Polish, and Latvian ones. They differ in content (gastronomic and wine tourism, event, farm, environmental, educational and sports tourism), the nature of interaction between agricultural and recreational activities (leisure and work directly in the field or in the garden, acquaintance with life, gastronomy and care of animals, participation in festivals), the forms of accommodation for tourists (accommodation in a village, in a farmer's house, in recreational cottages, in tent camps), and the nature of the service (contact with the farmer's family or facilities for self-service). The percentage of vacationers in rural

Belgium is 25%, Denmark 35%, Germany 43%, Spain 27%, France 29%, Ireland 27%, Italy 11%, Holland 39%, England 28 %.

European organization Euroter defines rural tourism as a kind of tourism supporting development of agricultural regions, preservation of cultural heritage and ecology of the village, as well as revival of local traditions and products. This type of tourism is characterised by regional identification and satisfies the needs of tourists in accommodation, food, licensing and other services that contribute to the sustainable development of the social sphere [4].

One of the most important and the least studied, as noted above, is the spatial arrangement of rural tourism, as well as determining its role and place in the existing regional system of recreational tourism. In regions with a rich potential of recreational resources, as the experience of rural tourism development in European countries and in the western regions of Ukraine shows, agro-tourism facilities complement the established system of recreation areas, expanding the range of recreational services and accommodation facilities for holidaymakers. We consider that in the industrially developed and urbanized Dnipropetrovsk region belonging to the steppe zone of Ukraine recreational development of rural areas and, in particular, development of rural tourism is an alternative direction for solving the problem of mass suburban recreation in conditions of potential shortage of traditional recreational lands and a developed agricultural complex.

The solution of this problem covers a whole range of issues related, first of all, to search for new content and defining principles for building a system of places for suburban recreation, formed on a fundamentally new natural basis - an agricultural landscape, and also principles for integrating systems of agricultural and recreational entities with rural settlements.

Rural tourism in Dnipropetrovsk region takes only the first steps. However, there is a social demand and all the prerequisites for its development.

Dnipropetrovsk region has favorable natural and climatic conditions for development of recreation for people. It is located at the border of mixed forests and a steppe zone and is rich in unique water resources. The forest area is 5.3%. The existing network of health resorts, including sanatoriums, dispensaries, boarding houses with treatment (40), recreation centers (87) and children's camps for country rest (25) does not satisfy the needs of citizens for places of rest. The increase in the provision level of recreational landscape resources (now 57.5%) is possible due to reservation of new recreational zones and implementation of the program for the formation and development of the regional ecological network of Dnipropetrovsk region integrating a wide network of sites from the natural reserve fund (178 facilities, that is 2.93% of the province area) [12]. The natural reserve fund of the region includes natural reserves, regional landscape parks, sanctuaries (landscape, forest, botanical, hydrological, geological, ornithological, etc.), monuments of nature, reserved landmarks, and monuments of landscape art. The ecological network of the region is an uninterrupted network of natural corridors, natural areas, natural nuclei, and buffer zones, which unites natural landscapes into a spatially integrated system where priority is given to reserved areas, recreational and tourist activities, as well as ecological agricultural production. The ecological network unites around 400 villages of recreational attractiveness and accounts for 27.5% of the total number of villages in the region.

Dnipropetrovsk region has a rather rich historical and cultural potential. Under the protection of the state there are more than 10 thousand monuments as follows: archeology - 7870, including 13 objects of national value; history - 3457, including 10 objects of national value; monumental art - 125, architecture and urban development - 339 [12]. According to the historical periods of the investigated region development, monuments of material culture as potential objects of local historical (rural) tourism can be divided into the following types: - historical and archaeological heritage - monuments of archeology (burial mounds, cemeteries, burial places, sites, fortifications) dating from Paleolithic and Neolithic periods, copper and bronze, Scythians and Sarmatians, Cherniakhiv culture, Kievan Rus, Polovtsy and nomads; - historical and ethnographic heritage - monuments of the Zaporizhzhia Cossacks period of the 16th-18th centuries (a farmstead, the winter residence, a settlement, a fortress, a guard post, the Kosh of Zaporizhzhia Sich, Palanka center, fortification lines etc.) - architectural and ethnographic heritage - monuments of the XVII-XX centuries (religious buildings, public and residential buildings, production and fortification facilities etc.); - historical heritage - monuments of the XVII-XVIII centuries (places of historical battles and graves of historical personalities) [14, 15]. Many monuments have not survived to the present day. However, their descriptions are recorded in various historical documents, literary sources, legends transmitted from generation to generation, which may serve as a basis for their reproduction.

The peculiarity of Dnipropetrovsk region is that the recreational potential described above (natural complexes, water objects, objects of the nature reserve fund, objects of historical and cultural heritage, etc.) is located within the boundaries of agricultural areas and is deeply integrated into the rural settlement system of the region. This allows to draw a conclusion about the need for an integrated approach to solving the problem of organising recreation in the countryside and developing a system of recreational entities that involves a more complex structure of recreational activities in rural areas, compared with the content that nowadays is included in the concept of rural tourism.

Forming the system of agricultural and recreational formations presupposes solving a whole set of tasks such as: determination of elements and links of the system, classification and hierarchical co-ordination of the system elements, structural and planning arrangement, as well as boundaries of recreational formations regarding the nature and intensity of recreational development of agricultural areas.

A comprehensive analysis of agricultural areas in Dnipropetrovsk region has been carried out. The administrative and economic structure, as well as spatial arrangement of the regions, recreational potential and localization of recreational lands within the boundaries of the regions, the structure of an agricultural landscape and the system of rural settlement, the level of development of the social, engineering and transport infrastructure of the districts have been investigated.

The following system of agricultural and recreational formations (ARF) of Dnipropetrovsk region is proposed: agricultural and recreational area (ARA) is formed as an economic and recreational spatial planning complex, within the framework of which integration of agricultural, recreational, nature protection functions is carried out (Fig. 1). ARAs are formed as riverine recreation territories in rural areas and develop as a continuous extended strip along the riverbed. The structural and planning arrangement of the ARA is determined by the established structure of agricultural production and the structure of the cultivated land, the system of rural settlements, the network of transport and engineering communications, as well as established administrative and economic boundaries. ARA of the province are considered as a part of the regional ecosystem; - agricultural and recreational zone (ARZ) - a structure-forming element of the agricultural and recreational area. Within its borders, ARZ unites farms with a high recreational potential, on the basis of which agricultural and recreational complexes (ARC) are formed. The existing rural settlements within ARZ is a backbone network for developing a system of recreational villages (SRV). The typology of recreational villages as recreation and tourism service centers is determined by the status, the level of social infrastructure development, historical and cultural significance of the existing villages; - agricultural and recreational complex (ARC) - farms within an agricultural and recreational zone are considered to be agricultural and recreational complexes integrating within their borders recreational villages and agro-parks - primary elements of the agricultural and recreational formation system of rural areas (Fig.2). An agro-park (AP) is formed as a walking rest area. The structure-forming elements of an agro-park are unique landscapes, nature-protected complexes and objects, historical monuments, archeology, architecture, ethnography (exposition objects) united by a system of connections (tourist routes) in the structure of an agro-landscape (Fig. 3).

Recreational development of rural areas enhances expanding the range of recreational services for citizens at a different qualitative and content level, and also contributes to revival and preservation of historical and cultural heritage of the region in general and the Ukrainian village in particular ensuring activation of social and economic development of the regional rural areas.

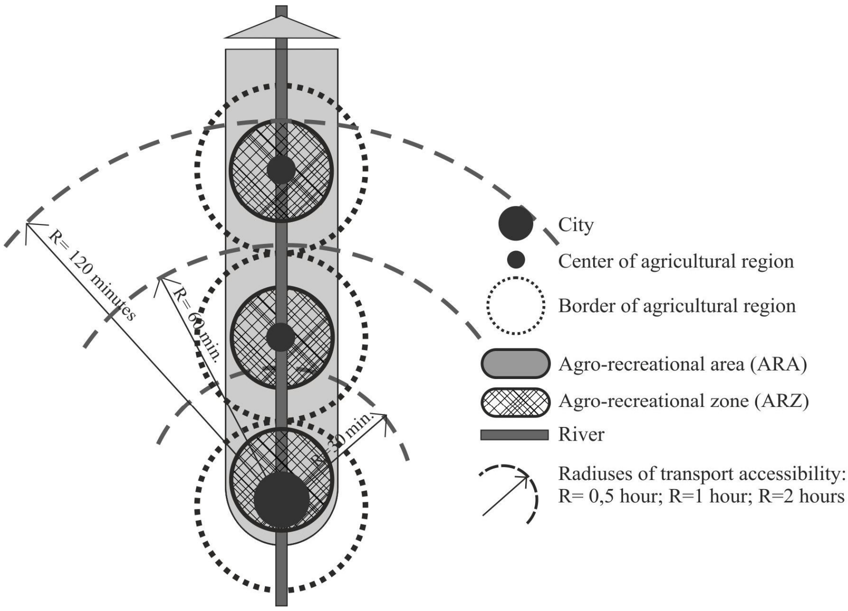

Fig. 1. Agricultural and recreational area (ARA) model

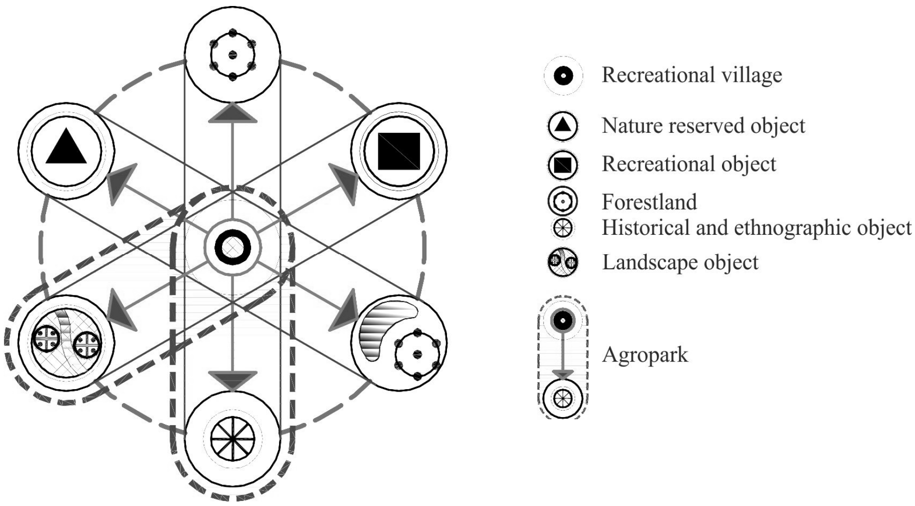

Fig. 2. Agricultural and recreational complex (ARC) model

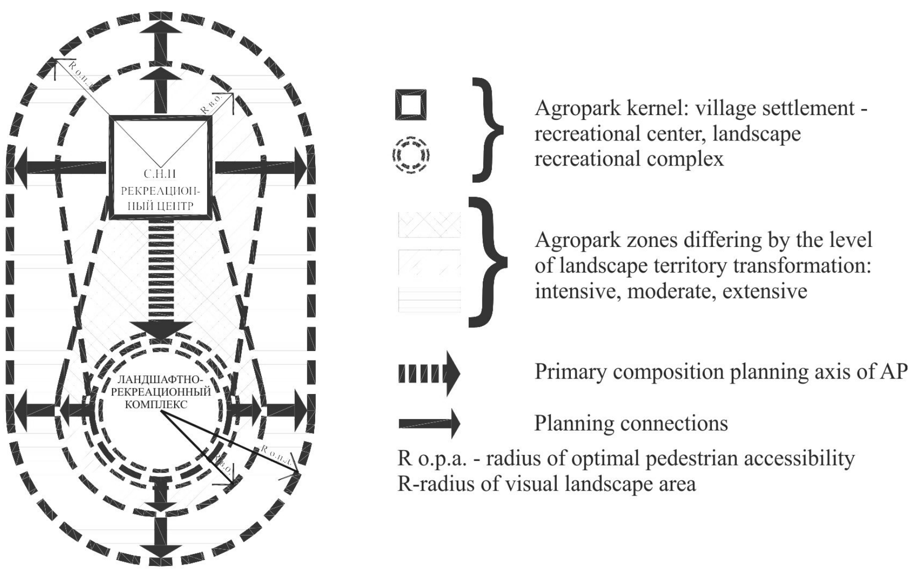

Fig. 3. Agro-park (AP) model

REFERENCES

1. Sostoianie i perspektivy razvitiia infrastruktury regionov Ukrainy Issledovaniia fonda imeni F. Eberta [State and prospects of infrastructure development in the regions of Ukraine. Research by F. Ebert's Fund]. - Kiev, Ukraine, 2014. Available at: http://www.fes.kiev.ua/new/wb/media/Infrastruktura (in Russian)
2. Luzhanskaya T.Y., Mahlina S.S. and others. Selsky turizm: istoriia, nastoiashcheie, perspektivy. Uchebnoie posobie [Rural tourism: history, present time, prospects. Training manual] / Ed. by Prof. I.M. Voloshyn - K: Concorde, 2008. - 385 p. Available at: http://tourism-book.com/pbooks/book-35/ru/chapter-1671/ (in Russian)
3. Latynin L.A., Primoliennaia L.M.. Gosudarstvennoie regulirovaniie razvitiia selskogo zelionogo turizma v Ukraine [State regulation of rural green tourism development in Ukraine]. Available at: http: //tourlib.net/statti_ukr/latynin.htm (in Russian)
4. Zarichnaia A.A.. Yevropeisky opyt razvitiia selskogo turizma. Ekonomika Kryma [European experience in the development of rural tourism. - The Economy of Crimea] №4 (37), 2011. pp. 265-269. Available at: http://tourlib.net/statti_tourism/zarichnaya.htm (in Russian)
5. Kudla N.E.. Selsky turizm: osnovy predprinimatelstva i gostiepriimstva. Uchebnoie posobie [Rural tourism: the foundations of entrepreneurship and hospitality. Tutorial]. - Publisher: Centre for educational literature. - Kiev, 2015. 151 p. (in Russian)
6. Lukomska O.I.. Sushnostnaia harakteristika selskogo zelionogo turizma. Problemy i perspektivy ekonomiki i upravleniia [Essential characteristic of rural green tourism. Problems and prospects of economics and management] No. 3. RSHU, Rivne, 2015. Available at: http://ppeu.stu.cn.ua/tmppdf/88 (in Russian)
7. Soiuz sodeistviia selskogmu zelionomu turizmu v Ukraine [Union for Promotion of Rural Green Tourism Development in Ukraine]. - 2015. Available at: http://www.greentour.com.ua/ukrainian/law/cabmin (in Russian)
8. Panchenko T.F. Turystychne seredovyshche: arhitektura, pryroda, infrastruktura [Tourism environment: architecture, nature, infrastructure]. - K.: Logos, 2009 (in Ukrainian)
9. Statystychni dani pro rekreatsiinu infrastrukturu Ukraiiny [Statistical data on recreational infrastructure of Ukraine]. Available at: http: //www.tourism.gov.ua/ua/information/registers (in Ukrainian)
10. Kyiivsky mizhnarodny instytut sotsiologii [Kyiv International Institute of Sociology]. Available at: http: //kiis.com.ua (in Ukrainian)
11. Rekreatsiina infrastruktura Dnipropetrovskoii oblasti (statystychni dani) [Recreational infrastructure of Dnipropetrovsk province (statistical data)]. Available at: http://www.dneprstat.gov.ua/statinfo (in Ukrainian)
12. Sostoianie rekreatsionnyh resursov I razvitiie kurortnyh zon: regionalny doklad o sostoianii prirodnoi okruzhaiushchei sredy v Dnepropetrovskoi oblasti za 2003-2016[State of recreational resources and development of resort areas: a regional report on the state of the environment in Dnipropetrovsk region for 2003-2016] - Dnipro, 2017. Available at: https://menr.gov.ua (in Russian)
13. Ofitsiiny portal Verhovnoii Rady Ukraiiny [Official portal of the Verkhovna Rada of Ukraine]. Available at: http://rada.gov.ua/ (in Ukrainian)
14. Yavornitsky D.I. Dniprovski porogy: geografichno-istorychny narys [The Dnipro rapids: geographical and historical essay]. - Dnipropetrovsk: Promin, 1989 (in Ukrainian)
15. Istoriia gorodov i sel USSR. Dnepropetrovskaia oblast [History of cities and villages of the Ukrainian SSR. Dnipropetrovsk region. - Kiev, 1969 (in Russian)

1.4. EXPERIENCE OF ARCHITECTURAL AND URBAN DEVELOPMENT OF AN AREA OF SEMANTIC INFLUENCE OF ETERNAL GLORY MONUMENT IN THE CITY OF DNIPRO

Podolynny Sergey, Nevgomonny Grygoriy, Boldyreva Olena

Relevance of the topic. After some interruption, the construction activity at the southeastern end of the main Avenue in the City of Dnipro near the title site of this area, the Monument of Eternal Glory, has been activated again. The construction process of a residential complex Panorama is completed. The construction of a residential apartment complex Resort City has begun and caused a significant negative resonance in the society. There is a necessity to discuss possible options for architectural and urban development of this area. At the same time, it is necessary to use those scientific recommendations that are expressed in urban ecology.

Evolution of approaches and problems of human interaction was considered in numerous scientific and journalistic publications [2, 5]. The theoretical basis is scientific development of such authors as Jacques Fresco (the USA) [4], V.M. Vadimov (Ukraine) [3], V.V. Vorobiiov (Ukraine) [4] etc. The purpose of the article is to clarify the principles of architectural and urban development activity in the contact points of the city architecture and the banks of the river Dnipro.

1. The 1930s. Two banks of the same river. After the commissioning Dneproges (Dnieper Hydroelectric Station) in 1932, the threat of floods was eliminated. There appeared an opportunity to develop coastal areas. In the general plan of 1933 (Fig. 1) several directions of access to the river are proposed. One of them is punching the axis of the main Avenue to the brow of the main hill and further visually and compositionally across the river Dnipro to the left bank. There this axis may be continued with a new avenue ending with a large square.

In this version, the Dnipro valley and the whole natural environment retain their dominant position. Architects solve their problems, harmoniously interacting with the nature. Obviously, they were guided more by the second part of the well-known statement of the famous biologist and breeder I.V. Michurin, "We can not wait for favours from nature, it is our task to take them from it. However, nature should be treated with respect and care and, if possible, preserved in its original form" [1]. For that time, it was a progressive, forward-looking approach, significantly different from very unpardonable to nature trends prevailing in the first half of the twentieth century.

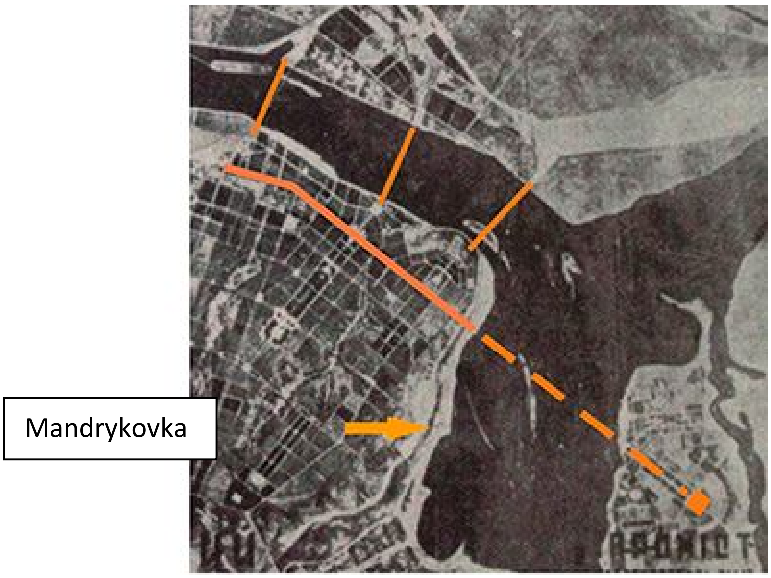

Fig. 1. Fragment of the general plan of Dnipropetrovsk (modern Dnipro) in 1933.

2. 1960th years. Large-scale benchmark. In the mid-60s, an interesting proposal concerning the formation of an outlet to the river was proposed by the architects V.A. Zuev and A.A. Miroshnichenko (Fig.2). It expands the problem of the avenue "meeting" the valley of the river. The entire embankment along the village Mandrykovka is included in the environment of compositional understanding.

In this project, an idea of more active development of the river valley and its coastal areas appears for the first time. There also emerges a vertical dominant - a hinge, a sign, a beacon - marking a particular contact point of nature and human creations (Fig.2.).

This dominant element is a kind of large-scale benchmark designed to emphasize the greatness and power of Nature. A man does not engage in a meaningless combat with it, there is a mutually beneficial cooperation. Significantly expanding the scale of architectural and city-planning solutions, the project, however, did not go beyond the second part of the Michurin's postulate "be respectful and careful about nature".

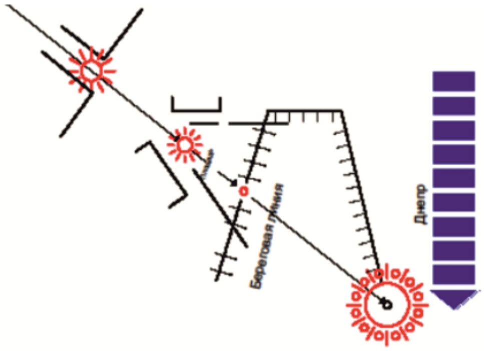

Fig.2. The design proposal of the architects V.A. Zuev, A.A. Miroshnichenko (in the mid-60s) and a model for analysis of compositional and spatial characteristics.

The semantic and compositional dominance of the Dnipro valley is emphasized by locating on a spit on the avenue axis a beacon-stela, the symbol of the unification of the City and the Great River. The project designated a place for a representative Monument which became the main accent of the coastal territory.

3. The 1960s. Cosmic atmosphere of the spot. The trend of the composition glorification and a more ambitious approach to the principles of area development has developed into erecting the Monument of Eternal Glory. Construction was preceded by an architectural competition. Unfortunately, the materials concerning this contest have not been found yet, therefore, reasoning can be based only on real results and memories of the direct participants of this event, I.I. Neskoromny and G.K. Klopko.

From the stories of famous Dnipropetrovsk architects, it follows that the contest presented many original projects. From their point of view, the winner did not present the most original version. Nevertheless, if we evaluate the peculiarities of interaction with the natural environment, it should be noted that the Monument fits perfectly into the structure of the basic landscape characteristics. The main thing is that it gives the feeling of unconditional supremacy of Nature due to its modest, chamber, figurative and artistic, dimensional and configurational characteristics. **It is just a sign, even if it's a sign of a world-known event. This is a hint, a place to stop, remember a story, bow to its heroes and ... see that life does not end there, it continues and can be as beautiful as the cosmic panoramas, unfolding from the platform at the foot of the Monument.**

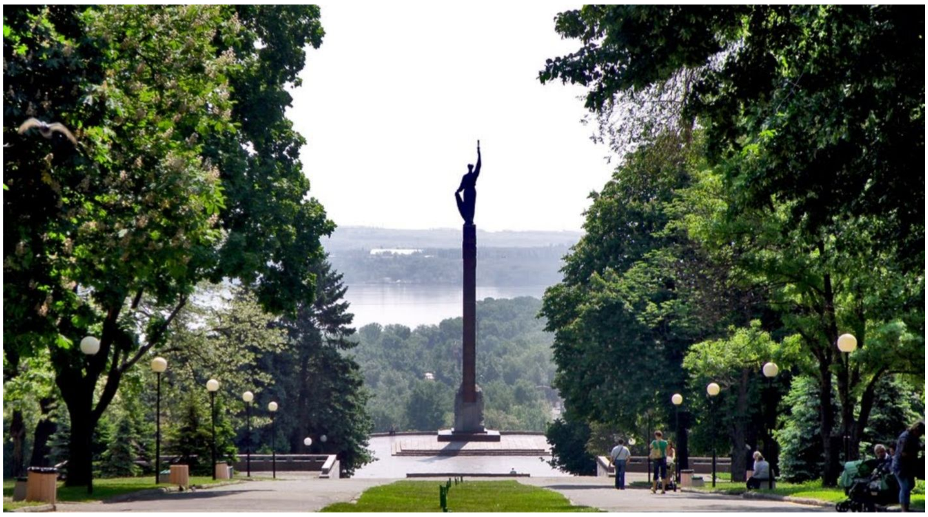

Fig.3. The view from the intersection of the Avenue with Simferopolskaia street

4. The end of the early-80s. 90s. Cosmic composition. The cosmic theme in the area became the basis of project proposals in the early 90s. The project, executed by the author's team under the leadership of L.S. Suponin (co-authors V.V. Kozlov, I. N. Zadoya) drew attention due to boldness and originality of the decisions and the grand scale (Fig. 5).

The leading topic is a "horizontal skyscraper". It continues the Avenue spatially and functionally to the river. There are two main dominants: a horizontal skyscraper, a group of high-rise buildings to the south of it and a background element - a glorified slope of a river terrace. They create a square at the Monument of Eternal Glory, however, in general, it loses its position of the semantic dominant. The space of the embankment is divided into two parts: in front of the skyscraper and behind the skyscraper.

Fig.4. Bird’s-eye view

Fig. 5. Analysis of compositional and spatial characteristics of the project proposal. Early 80s-90's.

This object could be clearly seen by astronauts of the orbital station. What will a pedestrian see at the foot of these structures and how does he perceive it? There probably are no unambiguous positive answers. The unconditional advantages of the project include the emergence of a new large-scale spatial element - a compositionally sensible, heroic slope of the river terrace. Without violating the meanings of the natural environment in architectural forms, one of the most characteristic features of the landscape is presented brightly and ingeniously. In general, the classical three-part composition (dominant, accent, background) charms with its perfection.

In this case the first part of Michurin's formula "do not wait for favours, take them" is beginning to dominate. This approach can be understood. At that time, it seemed that unclouded gracious prospects were opening, any futurism could be afforded, and the whole tragedy of environmental problems of the society has not yet been fully realized.

5. 2007, 2008 years. The harmonic interaction formula. The most important event in the process of understanding the principles of developing this area was the international contest of 2007-2008. In the tasks assigned to the contestants, the basic principles of what and how was required from architects were clearly formulated. Perhaps, the architectural and urban development decisions were not the brightest and the graphic design was not as refined as in other works. It was important that the winning project fulfilled the tasks of the contest to the greatest extent for the development of this area (Fig.6.). The main postulate of modern ecological urban development was expressed to a great extent: preservation of free, natural movement of substances, energy and information in any ecosystem. This is the basis for the safe and sustainable functioning of the living environment.

The jury (the Chairman Y.N. Belokon, Ph.D. (Architecture), Director of the Ukrainian State Institute Giprograd) managed to avoid superficial assessments and in his main choice made an emphasis on the priority of urban and semantic principles. The results of the competition in fact determined, clarified and confirmed the basic ideological basis for the development of the area.

The contest tasks:

- Formation of compositional accomplishment of the Avenue with visual opening of the Dnipro water area considering the importance of Eternal Glory Monument ;
- Finding a bright image of the Avenue meeting the river corresponding to the meaning of the event taking into account the significance of this image for the development of the panorama and outline of the city for viewing from the water area of the river Dnipro;

- Reaching harmonious inclusion of new building development into the current city fabric regarding development relevant to the general arrangement of the city;
- Providing economically appropriate usage of the area and investment attractiveness of prior construction objects.

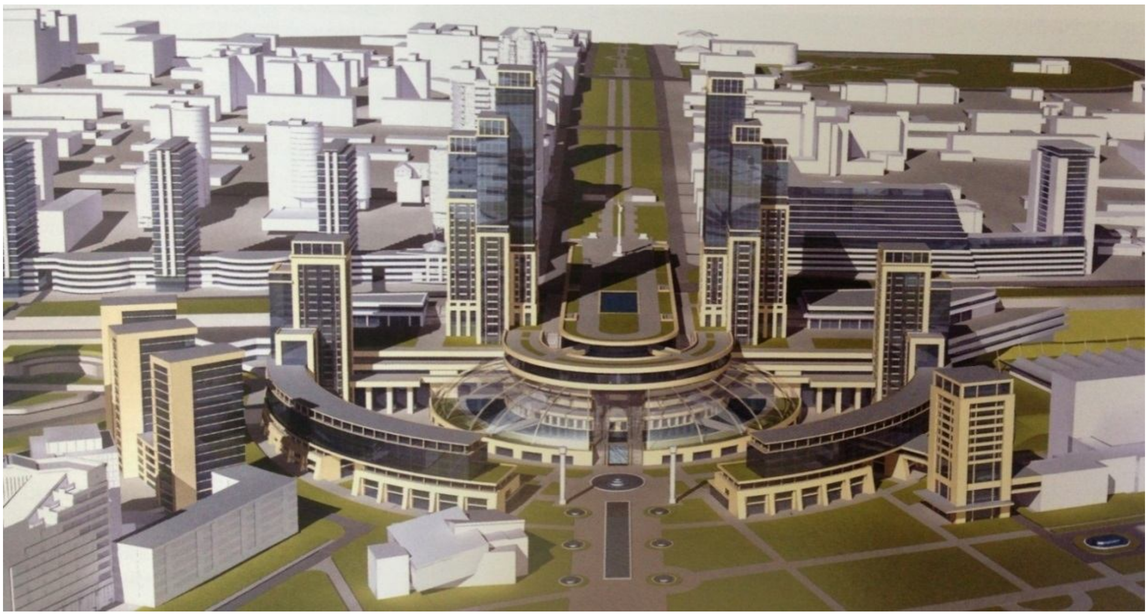

Fig. 6. The winning Project

The program of the competition was approved by all the main participants of architectural and urban development activity: the mayor of Dnipro I.I. Kulichenko, Chairman of the Regional Organization of Ukrainian Architects' National Union A.Y.

Shkovyra, Head of GlavApU (The Principal Architectural Office) of the City Executive Committee Y.V. Saenko, Director of the investment company E.A. Geller.

Conclusions. At the heart of modern approaches to architectural and urban development activity in this area, it is recommended to use those theses that were declared as the task of an open architectural competition. In the actualized modern interpretation they can be reduced to five main points:

- preservation of the modern semantic and compositional meaning of Eternal Glory Monument;
- providing a bright, memorable figurative and silhouette solution to panoramic views from the water area of the river Dnipro;
- preservation of free, wide visual opening of the Dnipro water area with viewing area near the Monument of Eternal Glory;
- the achievement of the organic inclusion of new architectural and urban development objects into the existing planning structure, taking into account the dominant role of modern ecological approaches;
- ensuring environmental feasibility and investment attractiveness primarily based on preservation and development of a positive image of the city.

REFERENCES

1. Michurin I.V. Izbrannie sochineniia [Selected works]. - M .: "Selkhozgiz", 1955.-p.606 (in Russian)
2. Dnepropetrovsk. Arkhitektory [Dnipropetrovsk.Architects] / N.P. Andrushchenko, M.E. Kavun, N.A. Lopatiuk and others; Under the Society. Rev. N.N. Condel - Perminova; - Kiev. Publishing House A - S., 2006 – 296 p. (in Russian)
3. Vadimov V. Gorod i reka (planirovochnyye aspekty) [City and river (planning aspects)] - Poltava: archeology. 2000-214p. (in Russian)
4. Vorobiev V.V. Obiiektivny ekopolis. /Stroitelstvo, materialovedenie, mashinostroienie: Sbornik nauchnykh trudov [An objective ecopolis. / Construction, Material Science, Mechanical Engineering: Compilation of scientific works. Issue No.75. - Dnipro, State Higher Educational Institution PSACEA, 2014. - pp.48-52 (in Russian)
5. Monument «Vechnaya Slava» - znakovy obiiekt v arkhitekture Dnepropetrovska serediny XX veka [The Monument of Eternal Glory as a significant landmark in the architecture of Dnipropetrovsk in the middle of XX century] / S.I. Genuine, Y.Y. Krylas // Visnik Prydniprovskoii derzhavnoii Akademii Budivnitstva ta arkhitectury: Zbirnyk naukovukh prats [Bulletin of Prydniprovsk State Academy of Building and Architecture: Compilation of scientific works]. - Dnipropetrovsk. 2013.- №5. – pp.51-56 (in Russian)

CHAPTER II
ARCHITECTURAL, STRUCTURAL AND TECHNOLOGICAL SYSTEMS FOR GREEN BUILDINGS

2.1. ENERGY SECURITY OF A LOW-RISE RESIDENTIAL ECOBUILDING "ZERO ENERGY" ON THE BASIS OF SOLAR ENERGY

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1. *Initial data.* The location of the house is a mid-European zone with the intensity of solar radiation - 1223 kWh / (m^2 year) (Ukraine, Dnipro). Residential house with the area of 130 m^2 is designed for a family consisting of 3...4 people. Dimensions of the building - 6 x 10 m, the longitudinal axis of the building is orientated east-west. The house is two-storey with an attic floor. The first floor is semi-basement. On it are located: kitchen-dining room, pantry, toilet, bathroom and room for sports activities. On the second floor are located: entrance hall, living room, bedroom, toilet, bathroom and study. On the attic floor there are: a hall, a room for utilities, a dressing room. The useful area of one floor is 50 m^2, the attic floor is 30 m^2. The height of the rooms on the floors is 2.5 m, the mansard floor is 2.2 m. The house has a thermal insulation with an estimated heat loss of 25 W/m^3. All household appliances in the house is designed to be powered by a single-phase electric current of 220 V, 50 Hz. As a prototype, a building with walls made of straw panels «Life House Building» [1] was chosen (see Fig.1, Fig. 2). The contract price is $ 350 per m^2 of the total area of the building.

2. Consumption of heat and electricity in the building. For the normal functioning of the projected house and the provision of comfortable living conditions for the people living in it, it is necessary to expend thermal and electric energy for the following functions:

- cooking and storage;
- heating (cooling) of air in the house to ensure comfortable living conditions for people;
- supply of cold water to the house and sewerage;

- heating of water for heating and hot water supply;

- functioning of household appliances;

- the functioning of the auxiliary objects of the manor (economic block, greenhouse, etc.);

- work of tools and devices of management.

Fig.1. The design of the house using straw panels

Fig. 2. Straw panel

The authors based on the statistical data, the experience of other specialists performed an analysis of the use of each consumer of energy during each month of the year, taking into account the duration of its operation and the power expended at the same time. The results of such an analysis are given in Table 1.

Table 1. Average power consumption by periods, kWh

Device	Power, W	Month												
		1	2	3	4	5	6	7	8	9	10	11	12	1-12
Basic regular consumers														
1	250	23	21	31	37	39	45	46	46	38	39	22	19	406
2	1200	112	101	112	108	112	72	74	74	144	112	90	93	1204
3	60	9	8	7	5	6	5	6	6	7	7	9	11	86
4	20	15	13	15	14	15	14	15	15	14	15	14	15	174
5	5	4	3	4	4	4	4	4	4	4	4	4	4	47
6	30	3	3	2	1	1	2	2	2	2	3	3	3	27
7	800	25	22	25	29	37	60	62	62	48	37	24	25	456
8	2500	194	175	116	30	30	20	20	20	25	124	188	194	1136
9	2500	47	42	46	45	31	22	16	16	22	31	45	43	406
10	150	9	8	9	9	14	18	19	19	14	12	9	7	147
	1x20 1x20 2x20 4x20	1 4 10 15	1 3 9 13	1 3 9 15	1 3 7 12	1 1 5 7	- - 2 5	- - 2 5	- - 2 5	1 1 2 5	1 1 5 10	1 1 7 14	2 2 10 20	
	total	30	26	28	23	14	7	7	7	9	17	23	34	225
total		471	422	395	305	303	269	271	271	327	401	431	448	4314
Auxiliary regular consumers														
12	2000	10	12	12	8	8	10	10	10	10	10	12	12	124
13	1500	4	6	6	6	8	9	9	9	8	6	6	6	83
14	1500	9	12	12	12	12	12	12	12	12	9	9	9	132
15	1800	4	5	5	5	7	9	9	9	7	5	4	4	73
16	50	1	1	1	1	1	1	1	1	1	1	1	1	12
total		**28**	**36**	**36**	**32**	**36**	**41**	**41**	**41**	**38**	**31**	**32**	**32**	**424**
Irregular consumers														
17	1500	-	-	2	3	4	6	8	8	4	-	-	-	35
18	1500	-	-	3	4	4	6	8	8	4	-	1	-	38
19	3200	-	-	3	5	6	10	10	6	3	-	3	-	46
20	1500	-	-	2	4	-	-	3	9	6	2	-	-	26
21	1000	-	-	-	1	4	4	4	4	4	2	-	-	23
22	320	-	-	15	19	1								34
total		-	-	25	36	19	26	33	35	21	4	4	-	202
total		499	458	456	373	358	336	345	347	386	436	467	480	4941

Note: 1 - refrigerator, 2 - kitchen stove, 3 - TV, 4 - inverter, 5 - charge controller, 6 - laptop, 7 - cold water pump, 8 - heat generator, 9 - electric kettle, 10 - air recuperator, 11 - lighting lamps, 12 - electric oven, 13 - washing machine, 14 - iron, 15 - vacuum cleaner, 16 - kitchen extractor, 17 - cutting machine, 18 - electric drill, 19 - welding machine, 20 - plant crusher, 21 - lawn mower, 22 - pump greenhouses.

3. Calculation of solar panels based on the determination of solar activity. The city of Dnipro has the following geographical coordinates in the world coordinate system WGS [2]: 48 deg 27 min northern latitude, 34 degrees 59 min eastern longitude. The duration of daylight hours in civil twilight is equal to: the shortest is 9 hours 36 minutes, the longest - 17 hours 26 min. The minimum design time for active solar radiation is 9 hours 36 min - 2 hours. = 7 hours 36 min (7.6 hours).

Solar insolation in Dnipro according to NASA data is equal to: annual - 1223 kWh / m^2 / year, average monthly - 3,3516 kWh/m^2/day [3]. The values of daily insolation by months are shown in Table 2.

Table 2. The average monthly level of solar radiation (solar constant) in the city of Dnipro, kWh / m2 / day

Month	1	2	3	4	5	6	7	8	9	10	11	12
Irradiation	1,21	1,99	2,98	4,05	5,55	5,57	5,70	5,08	3,66	2,27	1,2	0,96

To electrically supply the building, we select an autonomous solar power plant whose scheme is shown in Fig. 2 [4].

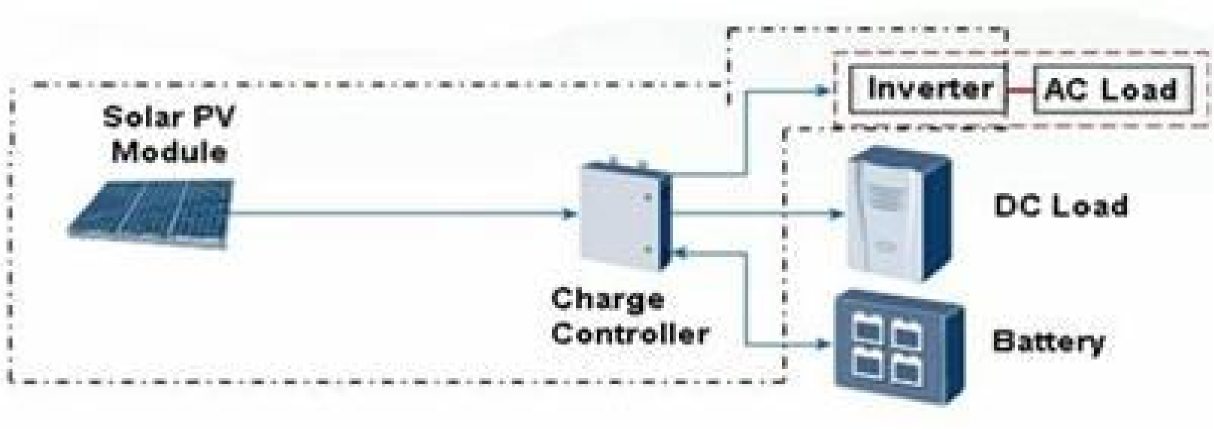

Fig. 2. Scheme of an autonomous solar power station

As a working we choose polycrystalline panel ABISolar PS-P60250 with a power of 250 W, voltage 24 V. The panel size is 1650x992x35 mm, weight -20 kg, the active area of the panel is 1.6368 sq.m. The cost of the panel is 250 dollars USA [5].

The panels are fixed on the southern roof slope of the designed house. The size of the roof slope is 3.7 m x 10 m. The angle of slope of the ramp is approximately 37 degrees to the horizon. According to the recommendations, solar panels should be placed at an angle to the horizon at an angle of 15 degrees more than the geographical latitude of the installation site, i.e. 48 + 15 = 63 deg.

The number of panels is dictated by the amount of electricity demand for the most unfavorable months of the year - in January and December. The required number of panels for electricity consumption in January: 497.5 / 1.21x1.6368 = 8.1. The same for December consumption: 477.9 / 0.96x1.6368 = 9.8. We accept for operation 10 panels in a solar battery. Table 3 shows data on generation volumes and requirements by months of the year for all 10 panels

Table 3. Consumption and generation of electrical energy, kWh

Parameter	Month												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
generation	613	912	1512	1989	2816	2735	2892	2577	1797	1152	589	487	20080
consumption	499	458	456	373	358	336	345	347	386	436	467	480	4941
difference	114	454	1056	1616	2458	2399	2547	2230	1411	716	122	7	15139

4. Calculation of auxiliary equipment. Inverter. The power of the inverter is calculated by the most intense month-January. Consumption in this month is 497 kWh, i.e. for the day 497/31 = 16 kWh. The duration of active solar radiation in January is 7.6 hours. The power of the inverter should be at least 16 / 7.6 = 2 kW, and taking into account the reserve 1.4 × 2 = 2.8 kW. We accept the power of the inverter 3 kW. Since the house is fully provided with electricity from solar panels, we choose a hybrid inverter for single-phase current of 220 V, 50 Hz and with a clean sinusoid.

It is recommended to use a hybrid inverter PH3000-3K (Taiwan). Its brief technical characteristics: nominal power - 3000 W, voltage: input - 24.48 volts, output -230 V, charge current - 80 A, weight 29.5 kg. The cost is $1003.

The backup electric system can be an industrial power grid, and where it does not exist - an autonomous unit of an internal combustion engine - a generator with a capacity of about 4 kW.

Rechargeable batteries. The total battery capacity is chosen for the largest monthly consumption. Daily consumption in January is 16048 Wh. We take the following distribution of this consumption: in the afternoon from solar batteries - 40% and at night from accumulators - 60%. Then the daily consumption of batteries is 16048x0.6 = 9629 Wh. The required battery capacity is: 9629/24 = 401 Ah. To ensure the longevity of batteries, their discharge should be no more than 80%. Therefore, you need a battery with a capacity of 401 / 0.8 = 501 Ah. We accept a 6 OpzV 600 battery with 600 Ah capacity and 2 V voltage. For a 24 V battery, 12 such batteries are needed. The Kharkov accumulator factory "Vladar" produces such batteries. These batteries are a new generation of gel, with panzer electrodes, with a service life of up to 18 years.

Charge Controller. We select the effective charge controller MPRT type - MORNINGSTAR TRISTAR-MPPT60 with the following technical characteristics: maximum continuous current of battery charge - 60 A, nominal voltage - 12, 24, 48 V, cost - 886 US dollars.

On the basis of the solar power plant calculator [6] in Table 4, indicative calculations of the parameters and cost of SES are given when choosing different power stations.

5. Variants of power supply of the building according to the scheme and without a "green tariff" scheme. The Ukrainian legislation allows for the transfer of surplus electricity generated by solar power stations of individuals to the country's industrial network. The order of such transfer is regulated by the Resolution of the National Council of Ukraine on February 27, 2014 No. 170. This resolution determines the requirements for a counter of such energy that it should be bidirectional. As a recommendation, you can offer, for example, a single-phase, bidirectional, multi-tariff meter MTX1A10.DF.2ZO-CO4 (Odessa). Its price is 41 US dollar. The use of a "green tariff" requires mandatory legal registration.

The economic efficiency of the use of solar batteries and the "green tariff" is determined not only by the gain from the sale of surplus energy, but also by the absence of payment for the consumed energy. Using the currently known tariff for consumed electricity (from 01.03.2017), which determines the cost of a monthly payment in the amount of 0.035 USD / kWh (up to 100 kWh / month) and 0.065 USD / kWh (more than 100 kWh / month), as well as the approved "green tariff" from 01.01.2017 to 31.12.2019 in the amount of 0,205USD/kWh one can determine the annual economic efficiency: Э = 12x100x0,035 + (4941-12x100) x0.065 + 15139x0.205 = 3388 USD.

Table 4. Approximate calculations of parameters and cost of SES when choosing different power stations

Parameter of autonomous SES	Power station, kW		
	3	5	10
number of photomodules, pcs	12	20	40
area of photomodules, m^2	19	32	65
angle of incline, degree	63	63	63
autonomy, hours	24	24	24
Battery Type	not served Ventura AGM GPL-200		
winter consumption per month kWh	500	500	500
consumption in summer in a month, kWh	350	350	350
generation of solar power plant per year, kWh	3298	5496	10996
annual consumption of the facility, kWh	5212	5212	5212
not compensated by the electric power station, kWh	2 221	1411	534
compensated electricity by the station, kWh	2 991	3801	4 678
capacity of storage batteries, kWh	33.6	33,6	33.6
number of batteries, pcs	14	14	14
estimated cost of the power plant, USD	9750	12150	18150

If for any reason will not the possibility of selling excess electricity, and then develop it fully would be no point. In this case, it is necessary in each specific period to use a limited number of solar panels, which will be dictated by the amount of energy consumed. This option of using panels can significantly extend their durability. Table 4 shows the calculation of generation and consumption by period, taking into account the rational number of used panels.

Table 4. Generation and consumption of electricity in the absence of a "green tariff" scheme, kWh.

Parameter	Month												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
generation	552	547	454	398	563	547	578	516	539	461	471	487	6113
consumption	499	458	456	373	358	336	345	347	386	436	467	480	4941
difference	53	89	0	25	205	211	233	169	153	25	4	7	1172
number of panels	9	6	3	2	2	2	2	2	3	4	8	10	

6. Ventilation and heat recovery system. When complete the residential buildings with plastic sealed window blocks, a good thermal insulation is provided, but there is a problem of air exchange in the premises. It is necessary to ventilate them periodically. However, in cold weather it is necessary to supply cold air to the rooms, which significantly breaks the thermal temperature regime in the rooms. Calculations and practice proved that through ventilation in winter, up to 50% of the heat energy is lost. There is a need to conserve this heat and at the same time to ensure ventilation. Systems of this designation are called recuperative.

An example of a successful implementation of such a system is the installation of VENTS MICRA 150E in the Poltava Ventilation Plant, which provides both ventilation and heat recovery. The advantage of this installation is also the availability of the function of heating the outside air. The unit has two fans with a total capacity of 15.5 W and a capacity of up to 150 m^3 / min. The weight of the installation is 20 kg, the cost is 1062 USD.

The second successful example is the recuperators of the company "PRANA", Lviv. These are recuperators for point use and must be installed in each room. Their brief characteristics: air flow - 125 m^3/h, air extraction - 115 m^3/hour, power consumption -32 Wh, room area - up to 60 m^2.

7. Water heating system for heating and hot water supply. The basis of such a system is an electric heat generator. The best technical solution at present is a heat generator with electromagnetic induction heating. It has the following advantages over other types of electric heating:

- absolutely fireproof, because flameless heating;
- the system does not form a scale;
- great durability (up to 30 years);
- silent operation;
- high profitability;
- the system can work on antifreeze.

Let us determine the thermal power of the heat generator. For a residential building with a heat consumption of 25 W/m^3, the required heat output is: (100 x 2.5 + 30 x 2.2) x 25 = 7900 W.

Based on the characteristics of the VENTS MICRA 150E and PRANA-150 recuperators, where it is indicated that these heat exchangers return 80 ... 93% of heat (assuming 70% for calculations), it can be concluded that to provide normal heating it is necessary to refill 7900 x (1 - 0.7) = 2370 W of thermal power. Thus, the total power of the heat generator should be: 7900 + 2370 = 10270 W. We select for use induction boiler VIN-10 (Zaporozhye), which has the parameters:

- thermal power -10 kW,
- efficiency - 99%;
- weight - 40 kg;
- cost - 577 USD.

It should also be mentioned that hot summer water can easily be obtained using a solar collector installed, for example, on the roof and a large capacity storage tank installed and insulated on the attic floor. Table 5 shows the cost of building construction including engineering systems.

Main conclusions and proposals.

1. The results of the studies show that in the Central European zone of Ukraine, where Dnipro is located, it is possible to provide an autonomous power supply for a low-rise residential building.

2. The proposed electric power supply system allows generating an excess amount of electricity, which can be realized according to the "green tariff" scheme.

Table 5. The cost of building construction including engineering systems

No.	Element of the architectural,constructive and engineering system of the building	Cost, USD/m^2
1	Building box with a rough finish	350
2	Autonomous solar power plant with a power of 3 kW	75
3	Heat generator for heating and hot water supply	5
4	Thermal barrier system	50
5	Ventilation and heat recovery system	10
6	Water supply and sewerage system with appliances	20
	Total:	510

3. If the building is located in the area lack ofthe industrial power network, a system of selective use of solar panels is proposed to generate the amount of electricity that would be enough to cover the demand in each period of the year. This technique contributes to a significant extension of the life of solar panels and batteries.

4. Currently, the Ukrainian market has all the necessary devices for the proposed construction system. There is an opportunity to organize own manufacture of separate elements and components of engineering systems.

5. The cost of basic constructives and technological systems of eco-building "zero-energy" is determined, which indicates the competitiveness of the proposed solution.

REFERENCES

1. http://lifehousebuilding.com/.
2. http://dateandtime.info/ru/citycoordinates.php?id=70993084.
3. http://solnechniysvet.blogspot.com/p/blog-page.html.
4. https://www.google.com.ua/search?q=an+autonomous+solar+power+plant+w&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiQ2KCNh87aAhVIyKYKHWReCS8Q_AUIDCgD&biw=1356&bih=627#imgrc=-4BtQdY8kVrQpM:.
5. http://solar-tech.com.ua/solar-electricity/.
6. http://greenlogic.com.ua/calculator.php?type_station=3&type_panel=1&azimut= 179&reg=20&Vphoto=5&Numphoto=20&Sphoto=32&STphoto=64&Aphoto=63&avt=24&type_batt=3&Wz=500&Wl=350#result).

2.2. THE CONCEPT OF ECO-BUILDING "TRIPLE ZERO"

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The traditional economic model of consumption and use of natural resources is characterized by a linear approach, also known as "take-make-dispose". The materials are supplied, used and, are recycled as waste at the end of the life cycle. The long-term use of this model was due to the availability and low cost of natural resources. It is well-known that this approach creates negative external effects that include increased carbon emissions, unstable water extraction levels, and extensive ecosystem pollution. In addition, an increase in the population and the reduction of natural resources reserves also causes a number of social and environmental problems.

The construction industry is the main consumer of natural resources. About half of all non-renewable resources consumed by mankind are used in construction. The construction industry has a significant impact on most environmental factors. The main feature of the traditional construction industry is the excessive use of energy that affects the process of global warming and climate change. Energy is spent in the extraction of raw materials, production and transportation of materials, in the process of construction, operation, repair and eradication of buildings. According to many studies, up to 50% of carbon dioxide emissions come from the construction industry. In addition, at the disposal phase of the building damage to the environment may be equivalent to its impact throughout its life cycle [1]. All of these factors make construction one of the least sustainable industries in the world, but at the same time it is the most promising for the introduction of sustainable technologies and achieving the most visible result in reducing environmental impacts.

The main modern philosophy called to reduce the harmful effects of the industry on the environment - is the philosophy of sustainable development. To date, there are many terms for designing buildings that meet the needs of environmental conservation, designed with one purpose, all of them offer different solutions. To better understand this difference, let's look at the proposed classification in Fig. 1.

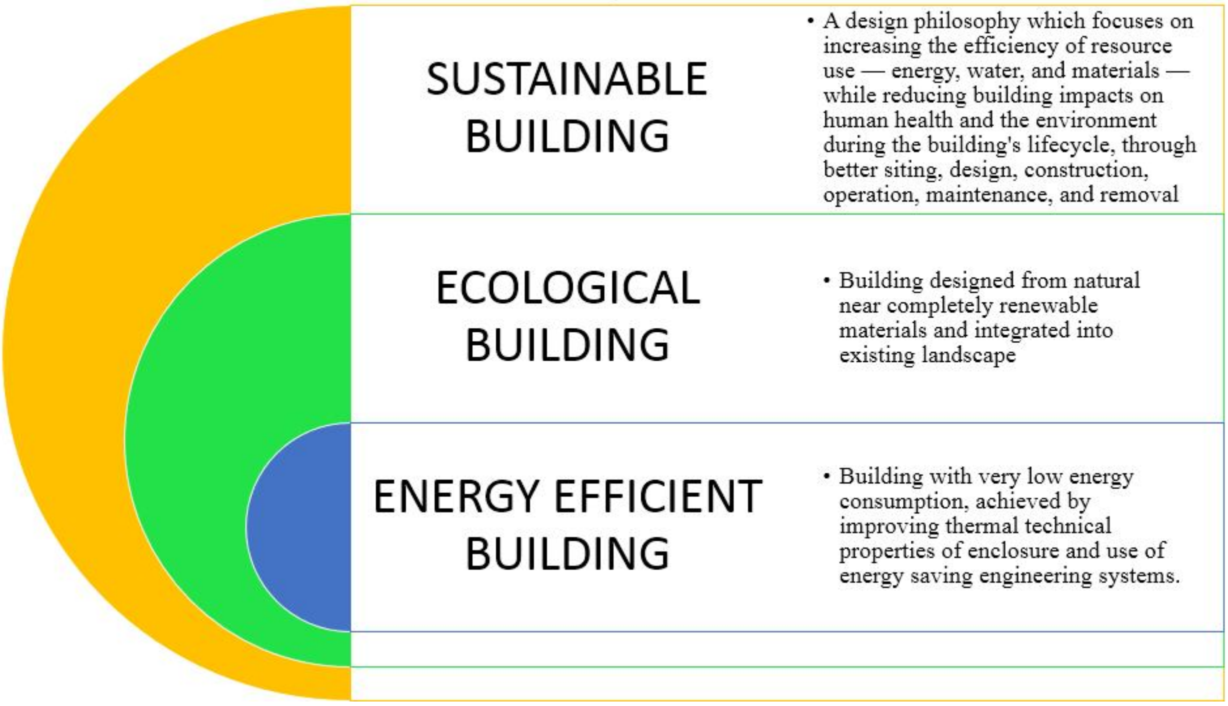


Fig.1. Constituents of the concept of sustainable construction

Based on the proposed classification, it can be concluded that only sustainable buildings include indicators of both energy efficiency and indicators of environmental efficiency or friendly attitude to the environment.

The concept of sustainable development is based on a combination of three components: economic, social and environmental. In recent years, it has been offered additional component - principle of preserving cultural heritage, as a separate, and not part of the social principle, as it was before.

The economic approach to sustainable development implies optimal use of raw resources and the use of environmental, energy, and material conservation technologies, including extraction and processing of raw materials, the creation of environmentally friendly products, minimization, recycling and disposal of waste.

The social component of sustainable development is oriented towards a person and aims at preserving the stability of social and cultural systems, including reducing the number of destructive conflicts between people. An important aspect of this approach is the fair sharing of benefits.

From an environmental point of view, sustainable development must ensure the integrity of biological and physical natural systems. Of particular importance is the viability of ecosystems, on which the global stability of the entire biosphere depends.

The concept of natural systems and habitats includes artificially created human environment, such as, for example, cities [2].

The building, territory, and the effects of the human impact on the environment today should be considered from the point of view of sustainable development, the components of which are environmental requirements for the construction site.

As a tool for implementing the principles of sustainable development in production by the European Commission, on December 2, 2015, a working program on the circular economy was adopted, which created an important incentive to support the transition to a resource-intensive economy in the EU. This package includes legislative proposals, with long-term goals aimed at reducing waste placement and increasing the amount of recycling and reuse [3].

The concept of the circular economy envisages the transition from a linear model to a model where natural capital is stored and developed, efficiently used energy resources, preventing the creation of untreated waste and reducing the amount of harmful emissions. Materials and products are made with the maximum possible use of renewable resources, and the exploitation of products is carried out in repetitive cycles.

Given the current state of the construction industry, one can be concluded that for a noticeable result in reducing the environmental impact, the implementation of the basic provisions of the theory of circular economy is necessary. In order to ensure the life cycle of the building, appropriate design is required taking into account the origin, production, transportation of materials and elements, as well as construction, operation, disassembly, processing or utilization. Preventing or minimizing negative impacts at each individual stage is critical to ensuring energy independence and environmental friendliness of the building as a whole [4].

In the general sense, this concept in simplification for the construction industry can be presented as an algorithm for switching from waste to resources, minimizing the use of raw materials (Fig. 3) depicts the conceptual model of interaction of measures on the transition to a circular economic system in construction.

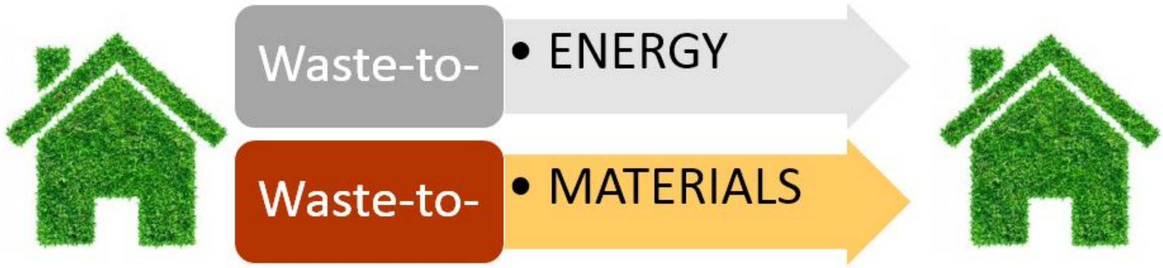


Fig.2. Circular economy in the construction sector

The first step towards the implementation of the principles of circular economy in the construction industry could be the development and implementation of energy autonomous ecological buildings with efficient waste management according to the following criteria (Fig. 4):

1) **Zero energy** – is to provide a balance of energy consumption, which will ensure the autonomy of the building throughout the lifetime of using rational design solutions, energy saving technologies (including renewable energy sources – sun, wind, biofuels, etc.), high-quality thermal insulation of premises.

2) **Zero emission** – is to minimize harmful emissions to humans and the environment (carbon dioxide, volatile organic substances, etc.),

3**) Zero waste** – includes measures to minimize the pathogenic effects of the building during its life cycle, including the use during the construction of only those materials that can be recycled or reused as raw materials, rationalization of waste management at the exploitation stage, the provision of light dismantling of building structures at the end of operation.

The concept of "Triple Zero" can be considered as a system of introduction of the circular economy into construction, and the circular economy itself as the main instrument for the implementation of sustainable development in the industry, including construction. Zero here is considered **not in the absolute, but in the conventional sense**, according to this concept, it is a question of **compensation on a global scale** (for the preservation of the ecology of the planet) and in the **local application** (concrete steps) of the principles of sustainable development (Fig. 3). At the same time, the global effect can only be achieved through an integrated approach that combines the principles of environmental and energy efficiency both in the reconstruction of buildings and in new construction.

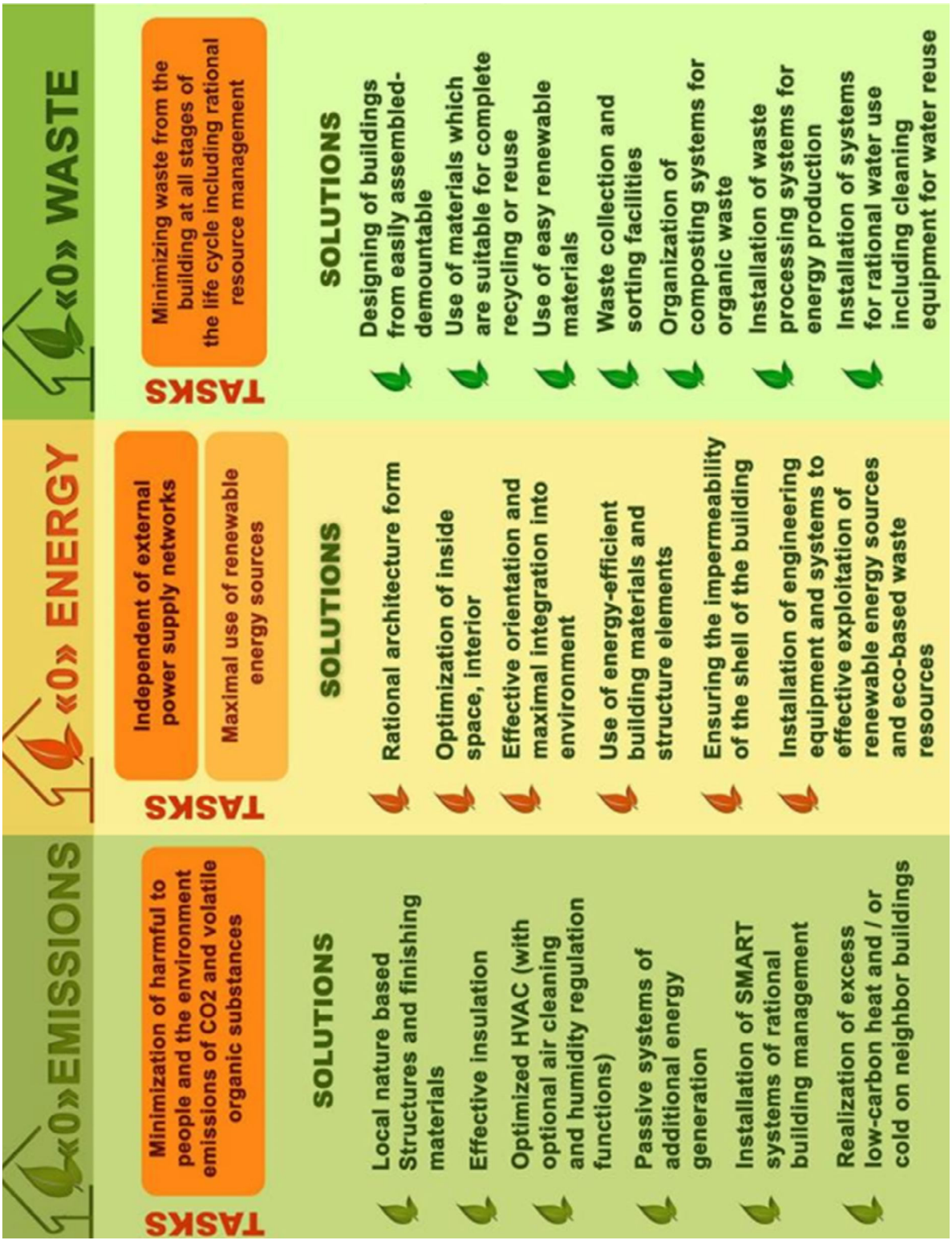


Fig. 3. Conception of building “Triple Zero”

Many principles that are associated with sustainable development and the circular economy are not new to Ukraine. Our construction industry supports, reuses, rebuilds or reorients infrastructure and buildings over the centuries. New approaches to design, new technologies already exist and apply.

Table 1. Matrix of "Triple Zero" building realization

		Principles of circular economy					
		Restoration	**Distribution**	**Optimization**	**Cycle**	**Virtualization**	**Alternative**
Components of the building	**Land plot (building site)**	Detoxification and restoration of the fertile layer (restoration of the local biosphere)	Systems for the cultivation of natural products, energy production, composting systems, etc.	Use of local renewable energy sources for own production	Restoration of site for reuse	Development of open source design through open, online platforms	Restoration in order to change the purpose of the plot
	Bearing elements	Structural solutions, structures and materials with a low impact on the ecosystem.	Reuse or recycling to change the scope of use	Durability and adaptability	Ability to recover or renovate. Change of purpose	Internet or BIM tracking system for technical state	Sustainable Building Approaches and Green Architecture
	Shell	Integration of green elements (facades, walls, roofs). Recycling for fertilization of green elements by composting	Easy disassembly	Sale of surplus production (fertilizers)	Modular elements of factory production	Internet or BIM tracking system for technical state	Sustainable Building Approaches and Green Architecture
	Interior space	Use of materials suitable for biorefining	Maximum use of useful space	Maximum use of natural light and ventilation	Restoration of elements using reused, repaired and new components	Interactive smart systems for monitoring the internal microclimate	Use of natural light and ventilation
	Engineering systems	Processing of food waste to low-carbon renewable energy	Reuse of components	Sale of excess energy	Collection of rain or melt water, recycling of used water	Smart sensors for monitoring and maintenance management remotely	Use of alternative natural renewable sources

However there is a lack of a specific structure of target design that links all existing and new principles and design approaches, taking into account the sustainable circular nature of the functionality of the building, including design, construction, operation, maintenance, repurpose and recycling. This requires a step-by-step transition to system approach to design, development and application of innovative technologies.

Thus, the implementation of the principles of sustainable development, taking into account the theory of the circular economy for a specific building, consists primarily in the design for effective functioning throughout the life cycle, and not simply end-use. The proposed concept of the Triple Zero building as a way to implement the principles of sustainable development and the circular economy offers an alternative approach to design, construction, operation and utilization. This approach is an opportunity to optimize the complex and multidimensional nature of the building as an artificially created environment.

Conclusion:

On the basis of the performed work on systematization and analysis the general principles of design of buildings "Triple Zero" are proposed. The implementation of the Triple Zero conception is a way to implement the principles of sustainable development and the circular economy into design of construction. The systematic use of this concept in terms of neighborhoods, cities, regions or the country as a whole will help to use less natural resources, reduce environmental impacts, reduce dependence on unstable markets, ensure transition to more sustainable forms of economic growth, urban living and value creation.

REFERENCES

1. The Impacts of Construction and the Built Environment [Електронний ресурс]. – 2010. – Режим доступу до ресурсу: www.willmottdixon.co.uk/asset/download/9462.
2. Du Pisani J. Sustainable development – historical roots of the concept [Електронний ресурс] / Jacobus A Du Pisani // Environmental Sciences. – 2007. – Режим доступу до ресурсу: http://www.tandfonline.com/doi/pdf/10.1080/15693430600688831
3. Closing the loop - An EU action plan for the Circular Economy [Електронний ресурс] // European Commission. – 2015. – Режим доступу до ресурсу: http://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF
4. Savytskyi, M. V., Bondarenko, O. I., Babenko, M. M. and Benderskyi, Yu.B., 2015. Options of sustainable development of region’s territory. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 4, pp. 157–161.

2.3. THE STUDY OF GEOLOGICAL HAZARD EXPANSION IN THE DNIPROPETROVSK REGION TO ENSURE ENVIRONMENTAL AND CONSTRUCTION SAFETY

Sedin Volodymyr, Grabovets Oksana

Currently, the thematic justification of the urban geological study is determined by the construction intensification, the need to assess the risk of geological hazard occurrence. The stability and dynamism of urbanized natural and anthropogenic geosystems in general are defined by a number of factors, among which the most important is the state of the underground hydrosphere. Environmental and construction safety is one of the topical issues. With new construction, reconstruction of old buildings, intensive development of underground space, the anthropogenic load on the geological environment increases many times. Correspondingly, geological and hydrogeological conditions are radically changing. The natural groundwater regime (level, temperature and hydrogeochemical) is disturbed. It often leads to the activation of negative engineering-geological processes and emergencies.

Economic damage of dangerous process consequence is enormous. Such circumstances are the result of a long-term disregard of the interrelated issues of engineering-geological and hydro-geological substantiation of economic and construction activities in modern megacities. However, the assessment of the existing natural and anthropogenic situation and the forecast of engineering and geological changes are practically impossible without detailed territory study.

Long-term unbalanced and planless economic activity on a large territory created real prerequisites for the active dangerous process development. Landslides, ground settlement above the mine openings, waterlogging, karst, erosion, mudflow, abrasion , processing of reservoir banks and suchlike are among the most dangerous for losses caused to economic objects. Since the end of the 70s of the last century, the degree of damage by geological hazards throughout Ukraine that have a planar and local distribution has increased by 1.5-2 times. This led to an elevation of the negative impact on the facility functioning.

Exogenous geological processes have been studied by a number of scientists [1, 2, 8, 11 - 15], but these are long-term processes, so we need to continue investigating them.

The initial information for writing this monograph is the production report data of the enterprises of the State Service of Geology and Mineral Resources of Ukraine of the Ministry of Ecology and Natural Resources of Ukraine "Annual Information Reports" [3 - 7].

The purpose of the work is to analyze the data of long-term monitoring of exogenous geological processes (waterlogging and landslide formation) on the Dnipropetrovsk region territory. According to DBN B.1.1-24: 2009 [3], such geological hazards as landslides, erosion, abrasion, waterlogging, and processing of reservoir banks were recorded within the Dnipropetrovsk region. Karst, ground settlement above the mine openings and loessial soil subsidence should be added to this list. Waterlogging and landslides are among the most dangerous geological processes. Let's consider them in more detail.

Waterlogging. The area of wet lands (with the groundwater level of 2 m in depth) in Dnepr is about 105.3 km^2, and an intensive rise in groundwater level (0.5-1.0 m per year) occurs on an area of more than 20 km^2. The annual losses associated with waterlogging are estimated at 10 - 12 thousand hryvna / Ha, and within Ukraine they are 1500000000 hryvna.

The dynamics of the waterlogging process is progressing. The data received to date show a trend towards activating the process on a regional scale and increasing the flooded areas (Table 1).

According to the results of surveys in 2017 the boundaries of the waterlogging areas in the Dnipropetrovsk region are 7.29 thousand km^2 (22.85%). Waterlogging is registered on the territory of 925 settlements, of which 18 are cities, 34 are townships and 873 are villages. Within settlements, waterlogging is due to the presence of an irrigation system, losses from the Dnipro-Donbass canal, groundwater dam by the Dneprodzerzhinsk Reservoir, the Orel, the Samara, the Bull and the Ternovka rivers damming and siltation, the construction on the flood plains and the absence of proper surface runoff. In many cases, previously drainage ditches are silted, covered and do not perform their functions. On the territory within Bogdanovka village - Ternovka waterlogging and partial water logging is caused by falsification of Samarskaya, Ternovskaya and Western Donbas mine workings. The cities of Dnepr, Kamenskoe, Krivoy Rog, Apostolovo, Zelenodolsk, Shirokoe, Ingulets, Volnogorsk, Ternovka, Pershotravensk, Pyatikhatki, Nikopol, Ordzhonikidze, Marganets, Gornitskoye, Sinelnikovo, Chaplino, Pereshchepino, Tsarichanka, Petrikovka, Novomoskovsk, Verhnedneprovsk, Pavlograd and etc. are waterlogged. The main factors in the process activation in the cities are the water pipe breakthroughs, the absence of centralized water disposal of reservoir, tailing dump groundwater dam, the Saksagan and the Ingulets rivers regulation, flooding of quarries and so forth.

The large-scale manifestation of waterlogging within Ukraine causes the emergence of other dangerous geological processes. Changing the state and properties of the natural massif, waterlogging creates the conditions for landslide occurrence or activation.

Table 1. Waterlogging districts of the Dnipropetrovsk region [4 – 7, 12]

Administrative formation	Waterlogging area, km^2	
	2007	2017
The Dnipropetrovsk region	7 262,9 (22,77 %)	7 290,0 (22,85 %)
Petrykivsky district	529,0	550,0
Nikopol district	448,0	535,2
Novomoskovsk district	413,0	470,0
Dnipropetrovsk district	413,0	507,8
Magdalenivsky district	383,0	549,5
Pavlograd district	370,0	483,4
Tsarichansky district	362,9	414,6
Shirokiv district	-	586,3

Landslides. Landslides are the result of the rock displacement on the slopes,that occurs owing to gravity. Landslides are characterized by various forms, volumes and rates of displacement [9].

The most common landslides are on the slopes and coastal areas, consisting of unstable rocks that have the ability to deform.

The landslide activation on landslide hazard area is under the influence of natural and anthropogenic factors. The main natural factors are meteorological (atmospheric precipitation, temperature, etc.), hydrological (water level and water discharge in surface waterways, water level and wave regime of water reservoirs), hydrogeological (levels, groundwater chemical composition and properties, its conditions of nourishment and drainage), etc. These factors are rapidly changing.

The duration of the period for the realization of their impact is from one day to a year. They determine the landslides activity. Their effect is realized through surface runoff, humidity, strength and deformation properties of rocks. There is a close relationship between the activity of landslide processes and the regime of precipitation and temperature changes both in the intra-annual and in the long-term. The impact of economic activity is associated with additional loading and cutting of slopes during construction works, creating dynamic loads on slopes, additional flooding of landslide hazard areas caused by excessive irrigation, pumping groundwater levels by reservoirs and other water bodies, water leaks from water facilities and communications, and so forth.

Along with other factors, increasing humidity and watering of soil near steep slopes of ravines and gullies also leads to intensification of landslide processes. The development of landslide processes causes the destruction and deformation of many industrial, engineering, residential and civil structures. Annually, significant material damage is caused to the state.

In the Dnepropetrovsk region the stage of landslide active development is observed in the cities of Dnepr, Krivoy Rog, Kamenskoe and Novoselovka village, Shirokovskiy district. In Dnepr there are more than 500 houses in the landslide areas, 40 houses of which are subject to resettlement, and about 50 houses are industrial enterprises. The activation recorded on the slopes of the beams – Krasnoye (4 landslides on an area of 0.15 km^2), Aptekarskaya, Krasnopovstanskoy, Sukhoy Yar in Dnepropetrovsk and Shamishnoi gully in Kamenskoye is especially dangerous.

The number of recorded landslides in the Dnipropetrovsk region in 1982 was

214, in 2002 it was 314, and in 2017 it was already 382 (the landslide area is 20.84 km^2). In 2017, anthropogenic activation of the landslide block was noted in the city of Dnepr on the right side of the Rybolovnaya gully (Kirova 92a, Nakhimova 90, Gavrilenko 10). The total area of the activated section is about 0.053 km^2. In the upper part of the gully slope there are garages (partially destroyed), schools (Nos. 22 and 75) and multi-storeyed houses. On the same slope of the gully below the top there is a private residential sector (Zakarpatskaya, Uzhhorodskaya, Nikopolskaya).

In the central part of the city, on the left slope of the Krasnaya gully (Goryanyaya and Rodnikovaya Streets, Krasnaya Balka Lane, Krasnaya Balka Dead End), there is a 0.025 km^2 sliding site with signs of activation. The causes of landslide activation are natural and anthropogenic: erosion of the gully slopes, made ground subsidence under buildings and the construction of the slope upper part. Landslides, located on the slopes of the gullies, are mainly frontal, with displacement mechanism - landslides-flows with flat slip. As a result of activation on the left slope of the Krasnaya gully, all the houses located along the Rodnikova street were damaged, four houses on the Goryana street (all are resettled) and three houses on the Krasnaya Balka lane (two are resettled). At repeated inspections, an increase in cracks in damaged houses is observed. Conducting anti-landslide measures or eliminating the consequences of landslide activation is not revealed.

In the central part of the city on the right slope of the Krasnopovstanska gully (Sera and Krasnopostanska Balka streets) there are landslides of block type. During the activation (from 1983 to 1997) several houses were destroyed and damaged, almost all residents from the Krasnopostanska Balka street were resettled. The causes of landslide formation are natural and anthropogenic: erosion on the slopes, construction on the upper part of the slope and ground soaking by leaks from communications. The total area of the activated section is about 0.067 km^2. During the spring survey in 2012, a small offset was found on the left slope of the gully spur (78, Lastochkina St.), where a private residential sector is located.

After the activations in1997 the terracing of the slope section on Sirko street, 54-56 was carried out with a gasket along the terraces of horizontal and reclined drainage trays. Now the trays are partially destroyed or covered. At the bottom of the gully and its spur, there is a closed (except for some sections) concrete drainage manifold. Also there were terraced slope sections in the area of 84-92 and 126-134 on Sirko street. A similar situation is observed in the Krasnopostanskiy Balka near the streets of Lastochkina (d. 76-78), Pirogov (d. 1-23), Saksaganskogo (d. 31A-45A), Prizavodskaya (110-120), Napornaya (56 A), Universitetska (d. 109-118). Recently, drainages have been filled with a mixture of clay and debris, where later local landfills will be formed.

In the city of Kamianske, an active sloping area is located on the right slope of Shamishin beams (Cheryomushki residential complex, Onischenko, Skalik, Tsiolkovskyi streets) in the central part of the city. This is an area of displacement-subsidence, where multi-storeyed buildings are located (residential complex "Cheryomushki"). There is no drainage system on the site, water runs along the slope surface. There are 8 resettled houses on the plot, 2 of them are disassembled (Onischenko Street). There are cracks between the blocks in three houses (Tsiolkovskii Str.). The total displacement area is about 6.4 hectares (0.064 km^2). In 2003, a partial concreting of the slope was conducted, and today everything is semi-defused. There are reports of the local population about crack progressing in the houses, but signs of a new shift on the soil surface were not detected. The slippery area in Kamyanets, Ostrovsky lane, the upper part of Barankikov beams, with a total area of 1.1 ha [12] is prone to activation.

On the right slope of the Kakhovka water reservoir in the area of Vyshetarasovka village, Tomakovsky district a landslide was formed under the influence of the erosion of the slope by the reservoir and the irrigation of nearby fields. The landslide gradually destroys the forest belt, which keeps it. On the adjacent territory of 0.088 km^2, repeated landslides are widespread. On the left side of the Volchya river valley in the area of Privolchanskoye, Pavlograd district longitudinal cracks are fixed, several shallow cracks are observed around the separation boundary, which is typical for zones of repeated landslide activation. The total activated area is about 0.030 km^2. Landslide activation is also observed in the cities of Krivoy Rog, Kamenskoe and Novoselovka village. [7].

Conclusions. Analysis of long-term monitoring data of waterlogging processes and landslide activation indicates a fundamental change in the exogenous dynamic development of slope landscapes in the face of technogenesis when there is an increase in the forms and scales of the disturbance of the upper zone of the geological environment: construction on the unfavorable sites, the growth of loads on surface and underground elements in industrial city agglomerations, degradation and aggressiveness of soil, which has a potential to subsidence, swelling, solubility and so forth. The general weakening of the soil upper zone increases rock mass propensity to activate geological hazards in quantity and timing.

The waterlogging process is in progress. The data obtained to date show a tendency the process to be intensified on a regional scale and the waterlogged areas to be increased.

In general, about 45 - 50 million UAH are needed annually to maintain existing state drainage systems and structures that protect the territories from waterlogging. [6], but as a result of financial security limitation for these purposes, no more than 3 to 3,500,000 UAH were allocated annually in the budget allocation limits. It is only 6-7% of the demand. Such a situation with funding cannot ensure drainage systems and structures' reliable functioning.

Analysis and assessment of the existing observation network indicates that the number of observation stations has significantly decreased in recent years. If in 1994 their total number was 334 (each station an average of 1.8 thousand km^2), then in 1999 there were 215 (one station for 3.0 thousand km^2), and now there are less than 100. Lack of observation stations is particularly felt in areas of intensive technogenic consequences - within the boundaries of mining enterprises, industrial-urban agglomerations. Observation data at such stations contributed to a timely response to the geological hazard activation. It helped to prevent emergencies, not to eliminate their consequences.

During 2010 - 2017 there was an aggravation of the geological and ecological situation. First of all, it concerns the landslides activation and waterlogging. Therefore studying the conditions for the development, distribution and activation of exogenous geological processes as well as organization their monitoring becomes a series of urgent issues.

REFERENCES

1.Actual problems of hydrogeology and engineering geology UkrSSR/[Iakovlev E.O., Shestopalov V.M., Zelinsky I.V., Shnukov E.F.]. – Moscow:"Science", Academy of scince of the USSR, 1988. – 290 p.

2. Goshovsky S.V. Ecological security of technonatural systems in connection with the catastrophical development of geological processes / Goshovsky S. V., Rudko G.I., Presner B.M. – Lviv - Kiev : Close corporation "Nichlava", 2002 – 624 p.

3. Protection of the dangerous geological processes. Fundamentals of the designing DBN B.1.1-24: 2009. – [Available from 2011-01-01]. – Kiev: Ministry of regional development and construction of Ukraine, 2010. – 73 p. – (National standard of Ukraine)

4. Information bulletin "Regional engineering-geological conditions of the territory in Ukraine"/[Demchishin M.G., Klimchuk L.M., Krasnook L.M. and others]; under the editorship of Iakovlev E.O. – [issue I, second edition , new-made and added], Kiev: Close corporation "Geoinform", 1997. – 92 p.

5. Information yearbook with regard to the activation of the dangerous exogenic geological processes on the territory of Ukraine according to the monitoring of EGP / [Krasnook L. M., Drapikovska I. I., Sergienko A. A.]; under the editorship of Biloshapska T.D., Velichko V.F. – Kiev: Government service of the geology and subsoil of Ukraine, Governement research-and-production enterprise "Governement informational geological fund of Ukraine", 2011. – ilustrated – 88 p.

6. Information yearbook with regard to the activation of the dangerous exogenic geological processes on the territory of Ukraine according to the monitoring of EGP / [Krasnook L. M., Riznyk T. O., Lysenko V.V. and others]; under the editorship of Klimchuk L.M. – [edition 4] – Kiev: Government service of the geology and subsoil of Ukraine, Governement research-and-production enterprise "Governement informational geological fund of Ukraine", 2007. – ilustrated – 22 p.

7. Information yearbook with regard to the activation of the dangerous exogenic geological processes on the territory of Ukraine according to the monitoring of EGP / [Krasnook L.M., Drapikovska I.I., Boyko K.E. and others]; under the editorship of Prymushko S.I., Biloshapska T.D., Velichko V.F. – Kiev: Government service of the geology and subsoil of Ukraine, Governement research-and-production enterprise "Governement informational geological fund of Ukraine", 2014. – 29 ilustrations – 101 p.

8. Lomtadze V.D. Engineering geology. Engineering geodynamics / Lomtadze V.D. – Lviv: "Funds", 1977. – 479 p.

9. Rudko G.I. Scientific and methodical basis of the monitoring of geological environment (engineering-geodynamic aspects). Ways of a study of the interconnected problems of the natural environment / Rudko G.I. – Lviv, 1995. – 132 p.

10. Modern engineering-geological conditions of Ukraine as a constituent of security of the life activity / [Klimchuk L.M., Blinov P.V., Velichko V.F. and others]; under the editorship of Blinov P.V., Shestopalov V.M. – Kiev: "Express", 2008 – 200 p.

11. Information yearbook with regard to the activation of the dangerous exogenic geological processes on the territory of Ukraine according to the monitoring of EGP / [Krasnook L.M., Drapikovska I.I., Boyko K.E. and others]; under the editorship of Prymushko S.I., Biloshapska T.D., Velichko V.F. – Kiev: Government service of the geology and subsoil of Ukraine, Governement research-and-production enterprise "Governement informational geological fund of Ukraine", 2014. – 29 ilustrations – 101 p.

2.4. ANALYSIS OF THE SOIL STRUCTURE INTERACTION UNDER SEISMIC INFLUENCE

Zagilsky Vitalyi, Sedin Volodymyr, Bikus Kateryna

Nuclear power plants (NPPs) are key components of the energy industry; the likelihood of extremely large damage from a potential accident of natural or man-made origin at facilities with potential environmental hazards determines an increased responsibility for the design and operation of nuclear power plant facilities and structures. Such threats are directly related to seismic phenomena, which can lead to ecological catastrophes with significant human losses.

According to regulatory documents, facilities of nuclear power plants require works on the examination and assessment of the technical condition of facility structures that contain important for the safety of nuclear power plants systems, which requires solving a number of specific problems. One of such problems is calculation of seismic resistance, as well as the floor-to-floor spectra of the facilities response in the "base – foundation – building" system [1, 2]. In the future, the calculated floor response spectra are used to qualify the equipment.

The feature of the NPP buildings and facilities response spectra calculation is the necessity of calculations at specific points of floor decks, where there are located important for the NPP safety systems.

For the NPP buildings and facilities response spectra calculation within the "base – foundation – building" system there are mainly used to methods:

1) Calculation of the facility that is represented in the form of bars with concentrated in nodes weight (building dynamic model).

2) Calculation of the facility, modeled in the form of 3D finite-element model.

In the first case, the simulation of the ground base occurs with the help of stiffness coefficients and damping coefficients. However, the use of the dynamic model of building, is located on a flexible base, does not allow to correctly calculate the floor response spectra at specific locations of equipment, which has an influence on further qualification of safety-related systems. In the second case, the modeling of a large-scale complex constructive scheme of a building (for example, reactor compartment) together with a bulk ground mass by the finite element method and calculation of the constructed model by a direct dynamic method is a complex task. In addition, the direct use of such a model increases the complexity of calculations.

Therefore, an improved method of dynamic analysis of interaction of a subsoil base and a facility for calculating of dynamic response of rigid massive buildings is proposed. This method combines the above two methods of calculation, which makes it possible to calculate the floor response spectra of massive buildings with a slab foundation at specific locations of equipment and reduce the complexity of calculations.

In the proposed method, the dynamic model is used to take into account the behavior of the studied facility under dynamic influence, and also to obtain corrected records of design seismic influences at the level of the foundation base of the facility, taking into account the effects of the soil base and the facility interaction.

In order to take into account the interaction of the elements of the "base – foundation – building" system in the proposed method, the soil is represented in the form of equivalent dynamic coefficients, which simulate stiffness and energy dissipation in the ground base. As base data, there is used seismic action at the level of the free surface of the site on which the building under study is located [3]. The result of calculation of the dynamic model of the building (rods with weight concentrated in the nodes) with the use of stiffness and damping coefficients is the recording of the seismic effect at the level of the foundation bed with consideration of the effects of interaction of the earth foundation and the facility.

For further calculations of the floor response spectra at specific locations of the equipment, a detailed FE model of the structure is used. The base data for the detailed FE model is the seismic effect at the level of the foundation bed, obtained at the stage of calculating the dynamic model of the building under study, taking into account the effects of interaction of the earth foundation and the facility.

The procedure of calculation according to the combined method is divided into the following steps:

1) construction of the building's FE model;

2) development of an equivalent building dynamic model;

3) calculation of the equivalent dynamic parameters of the earth foundation (stiffness and damping coefficients) in order to consider interactions in "base – foundation – building" system;

4) calculation of building dynamic model with superimposed dynamic parameters of the earth foundation to produce corrected exposure at the level of the facility foundation bed;

5) calculation of the FE model of the building under study for the seismic effect obtained on the basis of the previous stage.

Schematic representation of the combined method is shown in Fig. 1.

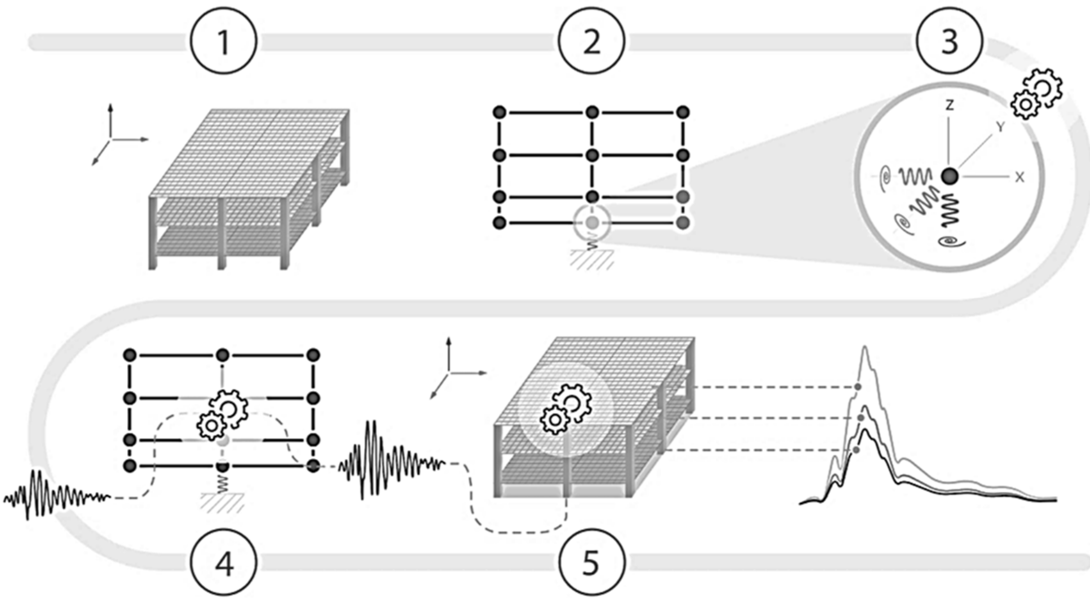


Fig. 1. Algorithm of the proposed combined method of calculation of the "base – foundation – building" system elements

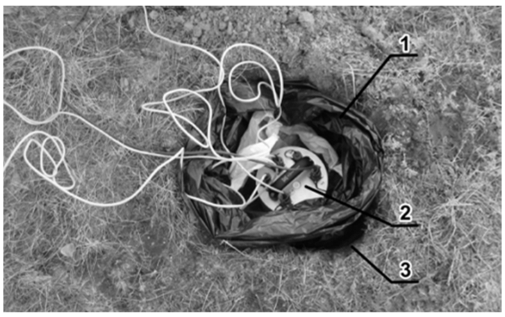
The combined method is adapted for calculation of the floor-to-floor response spectra of massive buildings and facilities with slab foundation at specific locations of equipment, which is essential for further qualification of systems important for the safety of nuclear power units. In addition, the application of this method reduces the complexity and time for calculations in comparison with the modeling of the earth foundation in the form of volume soil body.

To test the proposed method, there were carried out field studies on the interaction of the elements of the "base – foundation – building" system on a two-story skeleton structure with slab foundation.

A full-scale field study was carried out with the goal of creating a dynamic impact and recording relevant data at control points on the ground surface and at the elevations of the building under investigation in order to obtain qualitative and quantitative estimates of the transformation of the dynamic effect during its propagation from soil to the building and subsequent verification of the proposed combined method for calculation of interaction of the "base – foundation – building" system elements compliance with the results of full-scale study.

To record the dynamic impact on the site, as well as the dynamic impact on the building levels, a system called GURALP was used.

To record the dynamic impact on the ground surface in accordance with the technical documentation, the seismometer was installed in a prepared groove on a granite tile in a dense waterproof polyethylene package (Fig. 3a). When recording the dynamic impact on the building's marks, seismological equipment was installed directly on the structural elements of the facility under study (Figure 3b) [6].



a) b)

Fig. 3. Arrangement of temporary point of seismological observations: a) installation of seismological device in the ground (1 - waterproof material, 2 - seismological device, 3 - deepening), b) installation of seismological device at building levels.

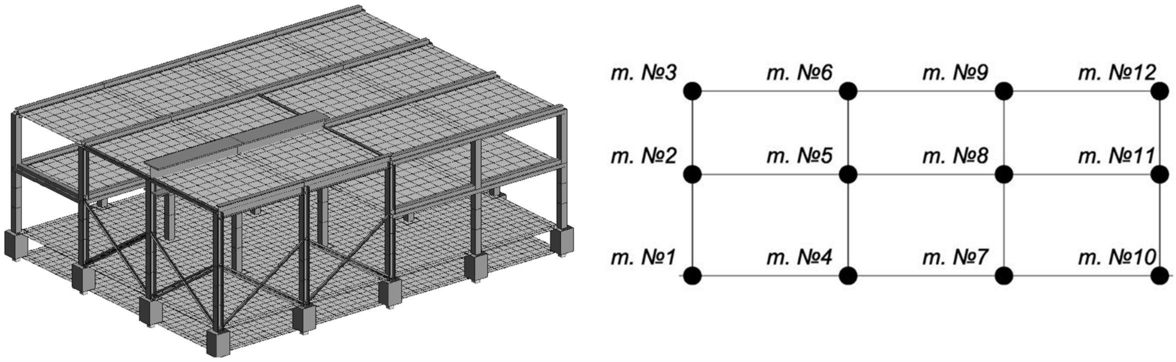
The dynamic impact was created by striking the embedded part of the plate with a size of 1 × 1 m with concrete breaker for 15 seconds (fig. 5).

Fig. 5. Installation of concrete breaker and the creation of dynamic impact

In the result of the field study, the records of dynamic impact on the soil surface and on the studied building levels are obtained [7].

To calculate the interaction of the earth foundation and the facility according to the proposed combined method, a three-dimensional FE model of the studied building was constructed. The construction was performed with the help of calculation complex Robot Structural Analysis. The FE model of the building is shown in Fig. 6a. Further, according to the calculation procedure of the combined method, a dynamic model of the building was developed. The dynamic model is used to represent the general characteristics of stiffness and inertial weight characteristics of building structures, as well as to obtain the resulting records of design effects at the foundation bed level (Fig. 6b).

Validation of the dynamic model of the facility under consideration consisted of two analyzes: static, which determines the total weight of the structure, and modal, which determines the characteristic oscillations of the structure, taking into account the attached fictitious weights from the loads. The obtained data were compared with the results of the 3D FE model of the building. The analysis of the results of proper frequencies and modes shows the proper convergence of the obtained data, the error of which is not more than 2%.



a) **b)**

Fig. 6. Design model of the building under studying:
a) FE model; b) dynamic model.

For further analysis, the equivalent dynamic parameters of the ground base (stiffness and damping coefficients) and the dynamic building model were combined, which is equivalent in weight and frequency to a three-dimensional FE system.

To verify the dynamic model with superimposed stiffness coefficients and damping coefficients, a comparative analysis of the proper frequencies of the first three waveforms obtained from the results of numerical and full-scale studies was carried out. The first forms of oscillation, as a rule, most qualitatively characterize the dynamic behavior of the building.

To determine the proper frequencies of the building under study, according to the results of the field experiment, a sample was taken from the recorded effects at the building level, where no disturbances (background noise) occurred. The spectrum of the characteristic frequencies of the building under study was obtained by means of the Fourier series transformation (Fig. 7).

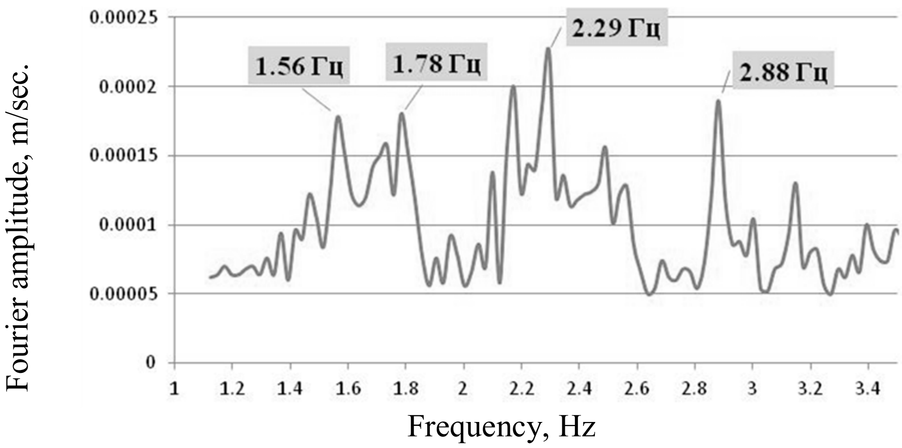


Fig. 7. The Fourier spectrum of the effects of background noise at the building levels

The analysis of the constructed Fourier spectrum of the effects of background noise at the building levels indicates that the first peak (1.56 Hz) refers to the frequency of the ground environment, while the other three peaks represent the first three proper frequencies of the building under study in the "base – foundation – construction" system.

The analysis of the proper frequencies of the building under study, obtained from the results of field and numerical studies, shows the proper correspondence of the numerical model to the real building. The error does not exceed 5%.

In order to obtain corrected effect at the level of the foundation bed, a dynamic model of the structure with superimposed equivalent dynamic parameters of the earth foundation was calculated. Then, we calculated the 3D FE model by direct dynamic analysis. For this purpose, loads were applied to the model simulating a dynamic effect of a given intensity in three directions. The initial data were accelerograms at the level of the foundation bed taking into account the interaction of the structure and the earth foundation, which were obtained at the stage of calculation of the dynamic model of the building. The calculation made it possible to take into account the effects of interaction between the earth foundation and the facility.

In the result of calculation of the 3D FE model, the floor response spectra were obtained at the control points of the building.

Comparison of the results of numerical and full-scale studies were made by comparing the maximum amplitudes of the accelerations at control points and comparing the Fourier spectra [4, 5], which in turn are used for frequency analysis of recorded effects in order to reveal the fundamental frequencies and patterns of their variation and amplitudes.

In the result of comparison of the maximum oscillation amplitude of numerical data and field survey data, it is found that, when using the proposed combined method, the difference in the results does not exceed 30%. From the analysis of Fourier spectra of recorded effects at control points obtained from the results of numerical and field studies, it is established that the Fourier spectra, constructed from the results of experimental and numerical studies (combined method), are fairly close at all contour points. The discrepancy in the amplitudes does not exceed 35%.

Moreover, in addition to the results obtained during the full-scale experiment, the results of the direct method of interaction between the elements of the "base – foundation – building" system (modeling of the soil by volume elements) are used to assess the convergence of the proposed combined method.

Numerical modeling of the direct method of interaction between the soil body and the studied building was carried out in the calculation complex Ansys. The studies were carried out in a three-dimensional arrangement, taking into account the actual layering of the foundation soils on which the building under study is located. The numerical model includes volume soil bed, building and elements of the foundation (Fig. 8).

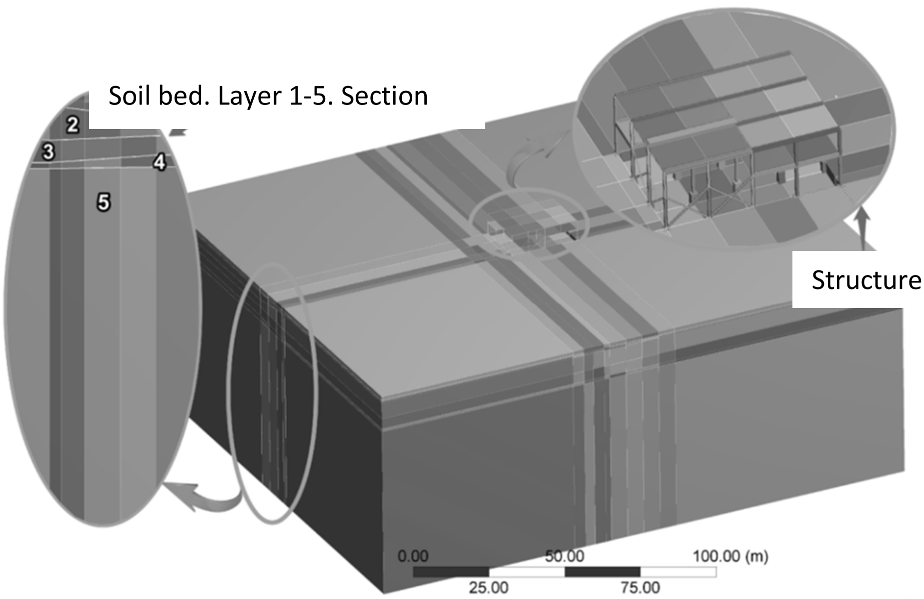


Fig. 8. Numerical model of the system BFB. Direct method of interaction

In the result of the calculation, kinematic parameters (displacement, velocity, acceleration) were obtained at the control points of the building. By comparing the maximum oscillation amplitude of numerical data and field survey data, it was found that the maximum error is 16.6%.

Simulation of the ground environment by volume elements in the calculation of the interaction of the elements of the "base – foundation – building" system shows the greatest convergence of results with experimental studies among all the methods of interaction of the soil foundation and structure, but its application is labor-intensive from a computational point of view and requires the solution of a number of specific problems.

The proposed combined method of calculating the "base – foundation – building" system at the seismic action of the method makes it possible to take into account the effects of interaction of the earth foundation and the structure. The proposed method, in comparison with the use of the three-dimensional finite element model together with the bulk soil bed, reduces the complexity and shortens the calculation time.

REFERENCES

1. Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants : Safety Guides NS-G-3.6 / International atomic energy agency. – Vienna, 2004. – 53 p.
2. Seismic Design and Qualification for Nuclear Power Plants : Safety Guides NS-G-1.6 / International atomic energy agency. – Vienna, 2003. – 67 p.
3. Mylonakis G. Footings under seismic loading: Analysis and design issues with emphasis on bridge foundations / G. Mylonakis, S. Nikolaou, G. Gazetas // Soil Dynamics and Earthquake Engineering. – 2006. – Vol. 26, iss. 9. – P. 824–853
4. Grib N. N. Analiz seysmicheskikh effektov ot massovykh vzryvov razreza "neryungrinskiy" [Analysis of seismic effects from mass explosions of the "non-Trungrinsky"] / N. N. Grib, A. Yu. Pazynich // Sovremennye problemy nauki i obrazovaniya [modern problems of science and education]. – 2010. – № 1. – p. 71–76.
5. Sakharov V. A. Vzaimodeystvie inzhenernykh konstruktsiy s nelineynym osnovaniem pri seysmicheskikh nagruzkakh : avtoref. dis. … dokt. tekhn. nauk : 05.23.02 [Interaction of engineering structures with a nonlinear base under seismic loads: author's abstract. dis. ... Dr. Sc. (Tech): 05.23.02]: / V. A. Sakharov; Kiïvs'kiy natsional'niy universitet budivnitstva i arkhitekturi [Kiev National University of Civil Engineering and Architecture]. – Kiev, 2015. – 41 p.
6. Triaxial Broadband Seismometer : Operator's guide: Güralp Systems Limited – England, 2006. – 35 p.
7. Sedin V. L. Naturnaya otsenka vzaimodeystviya osnovaniya i sooruzheniya pri udarnom vozdeystvii na grunt [Full-scale assessment of the soil structure interaction under force impact on soil] / V. L. Sedin, E. A. Bausk, V. A. Zagilsky // Stroitel'stvo, materialovedenie, mashinostroenie : sb. nauch. tr [Construction, material science, engineering: collection of scientific papers] / Pridnepr. gos. akad. str-va i arkhitektury [Pridneprovsk State Academy of Civil Engineering and Architecture]. – Dnipro, 2015. – rel. 85: Seriya: Innovatsionnye tekhnologii zhiznennogo tsikla obektov zhilishchno-grazhdanskogo, promyshlennogo i transportnogo naznacheniya [Series: Innovative technologies of the life cycle of housing, civil, industrial and transport objects]. – p. 62–67.

2.5. EXTENSION OF THE PERFORMANCE OF METALLIC SMOKE PIPES IN IMPROVING THE ECOLOGY OF REGIONS

Yarovoj Sergey, Dorofeev Eugene

When modernizing boiler equipment and reducing harmful emissions into the atmosphere, the question of extending the life of metal chimneys is urgent. Temperature influences and cyclic loads can lead to the appearance of cracks in the metal and welds of elements of metal chimneys and bearing towers. Corrosive effects of the environment and flue gases significantly accelerate the rate of development of cracks.

Before the crack was formed, the stresses along the pipe section were uniformly distributed and the trajectories of the principal stresses were rectilinear. After the formation of a crack in the metal or in the welded seam of the trunk, the main stress lines are curved and thickened, which characterizes the increase in stresses at the point of crack formation, and leads to the appearance of two principal stresses σ_1 and σ_2, i.e. the appearance of a plane stress state [1, 3]. In places where cracks form, the curvature of the main stress lines is similar, as in the formation of holes. But the condensation of the trajectories of the principal stresses is more pronounced, which leads to the formation of large stresses at the edges of the cracks (Fig. 1).

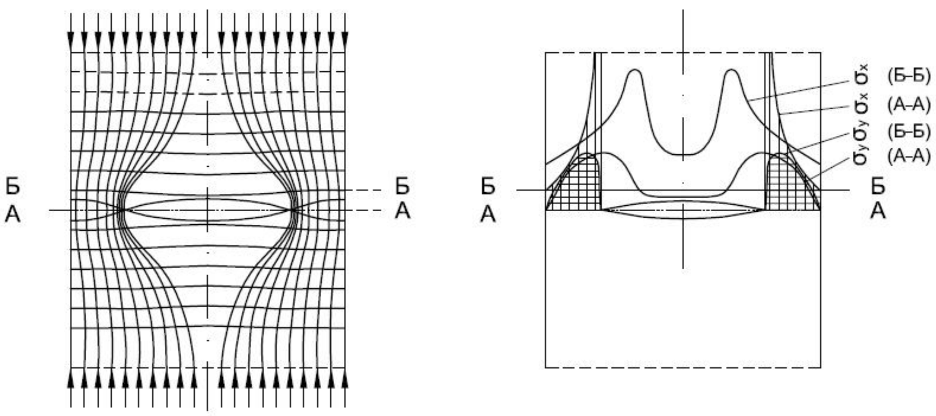


Fig. 1. Concentration of stress at the point of crack formation.

The radius of curvature r at the edge of the crack is very small. The coefficient of stress concentration $\alpha\sigma$ depends on the radius of curvature r - the smaller the radius of curvature, the higher the concentration coefficient. At the edge of the crack, the stress concentration coefficient reaches 6-9.

Theoretically, the radius of curvature of the crack edge r tends to infinity, and as a consequence, the stress concentration coefficient tends to infinity. The higher the stress concentration, the less plastic deformation. A sharp voltage drop and a single-valued field of tensile stresses hinders the development of plastic deformations. Less tense neighboring areas hamper their development. Destruction is fragile and takes place by detachment.

In practice, radiographic photographs show that even with an acute stress concentrator in the separation zone, there are areas with pronounced plastic flow.

With the help of the Selena-Results software complex, an elemental model with a crack in the welded seam at the base of the pipe was constructed (Fig. 2).

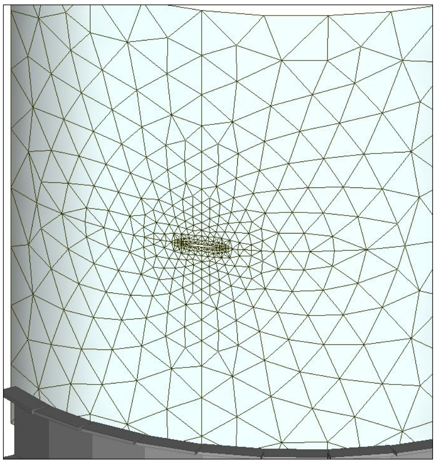


Fig. 2. The model of a crack in the horizontal seam of a pipe.

A crack length of 150 mm and a width of 5 mm in a horizontal welded joint between the pipe sections was revealed by examining a metal exhaust pipe 100 m high located inside the bearing tower of the nitric acid production department of the Chemical Combine Minudobreniya in Rossosh [11, 12]. The exhaust pipe was calculated taking into account the effect of its own weight and wind load.

The obtained results indicate that after the crack is formed in the horizontal welded seam of the trunk, the main stress lines are warped and thickened, which leads to the appearance of two main stresses σ_1 and σ_2.

In the place of the crack, there is a plane stress state. At the edges of the crack, where the stress concentration coefficient is maximum, there are areas with a pronounced plastic flow in the metal (Fig. 3).

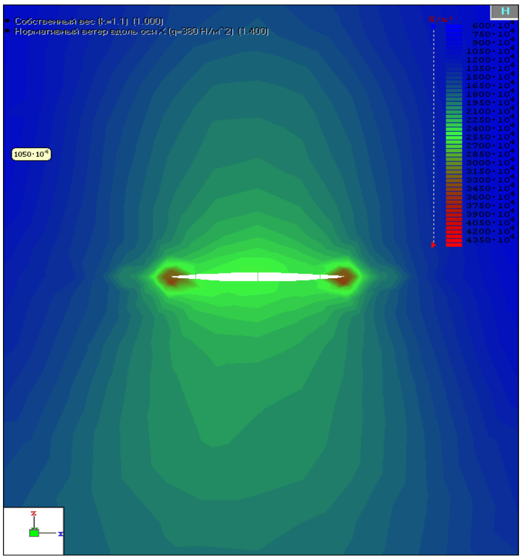


Fig. 3. Stress intensity in the vicinity of a crack.

In the presence of stress concentrators in the form of cracks, dynamic (wind) impacts and a sharp decrease in temperature (temperature shocks) have an extremely negative effect on the strength of metal exhaust pipes and elements of bearing exhaust towers.

The nonuniformity of stress distribution is characterized by the stress concentration coefficient α_σ

$$\alpha_\sigma = \sigma_{max} / \sigma_n, \tag{1}$$

where σ_{max} - is the maximum stress at the concentration site; σ_n - is the nominal voltage in the weakened section, equal to $\sigma_n = N / A_w$; A_w - is the area of the weakened section.

There is a regularity in reducing the stress concentration coefficient $\alpha\sigma$ from the gain of the K_c hole [6]. The gain of the hole is determined by the formula:

$$K_c = A_w / A_c , \tag{2}$$

where A_w and A_x are the areas of amplification and attenuation of the aperture.

The dependence of the stress concentration coefficient α_σ on the hole gain K_c is shown in Fig. 4.

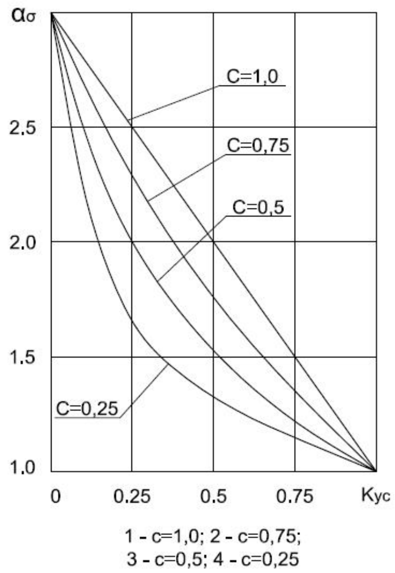


Fig. 4. Dependence of the stress concentration α_σ on the hole gain K_c.

The presented dependence is well described by the following formula:

$$\alpha_\sigma = 3 - 2/\, K_c^{con} \quad (3)$$

where con is a constant (con ≈ 0.5).

With the same thickness of the trunk of the pipe and the lining $K_c = 1.0$, $\alpha_\sigma = 1.0$.

When determining the load-bearing capacity of metal chimneys with overlays, weld corner joints play an important role, and their operability can be improved by rational choice of their properties and sizes. Increase of serviceability of welded seams is reached by increase of value of factor crack resistance K_c and optimum choice of parameters of overlays. Crack resistance K_c is improved by the choice of welding electrodes, the optimal welding regime, thermal treatment during welding or after welding.

As is known, the performance of welded elements is determined by the residual welding stresses, caused by the peculiarity of the thermal-deformation welding cycle, and in magnitude they are close to the yield point [7].

The process of forming a system of welding stresses when the stem of the chimney is strengthened by welding the lining (Figure 5).

σ_r, MPa

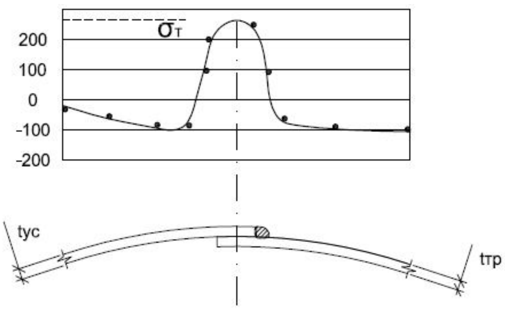


Fig. 5. Voltage distribution when welding overlaid elements

The thickness of the reinforcement plate t_{yc} at the point of the through hole usually corresponds to the wall thickness of the tube t_{tp}.

Welding stresses during welding at the place of reinforcement of the lining to the chimney arise due to localized processes of heating and cooling - structural transformations of the metal.

The most important condition is the appearance in some zones of structural elements of elastic-plastic deformations. When welding elements, the gradients of the temperature fields are such that they generate welding residual stresses. In this case, the maximum residual tensile stresses σ_r^{max} for well-welded low-carbon and low-alloy steels are realized in the center of the weld.

The maximum residual stresses σ_r^{max} are approximately equal to the yield strength of the weld metal σ_u^w. In the general case, $\sigma_r = \gamma\ \sigma_u^w$. The range of residual stresses is limited by the width of the "core" in which thermoplastic deformations occur. Such a pattern of distribution of welding stresses occurs when the welded element is in an unstressed state.

Elimination of fracture-like damage in operating chimneys by welding work is performed in structures under load. The features of the thermal cycle of welding of the overlaid elements are that the maximum residual stresses are realized in along the formation of the welded seam. The experience of repair work shows that the most dangerous from the point of view of working capacity are the ring seams. The level of initial damageability of the chimney to be repaired is determined by the value of the relative stress - $\overline{\sigma_{ok}} = \sigma_0 / \sigma_u$, where σ_u is the yield strength of the metal.

In the area of stress concentrators, the initial intensity level $\overline{\sigma_{ok}}$ can be larger in α_σ times: $\overline{\sigma_{ok}} = \alpha_\sigma \overline{\sigma_o}$, where α_σ is the stress concentration coefficient. The distribution of welding stresses, as a rule, is self-balanced, where the areas of the tensile and compressive stresses should be the same, regardless of the initial stresses.

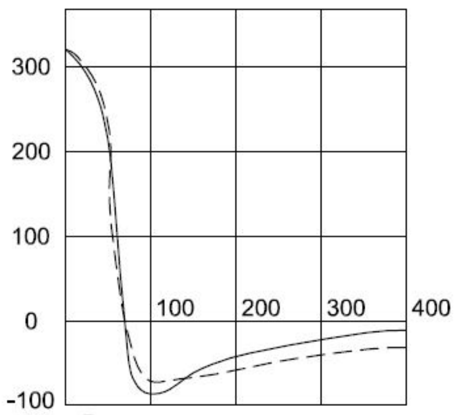
The distribution of welding stresses in the zone of annular welded pipe joints is described quite well by the function:

$$\sigma_r = \sigma_r^{\max \frac{1-\xi^2}{1-\xi^4}}, \tag{4}$$

where $\xi = 2x / B$ - relative coordinate, B - width of the core.

The experimental data practically correspond to the data obtained by the formula (4), and are presented in Fig. 6.

σ_r, MPa



Distance from center of weld

——— - by the formula (4); - - - experimental data

Fig. 6. Distribution of residual stresses prior to testing ($\sigma_b = 0$)

In the case where the yield stress of welded σ_u^w seams is different from the yield stress σ_u in formula (4), it is advisable to introduce the coefficient of mechanical inhomogeneity K_h =. σ_u^w / σ_u. Therefore, in the case of normal welding (non-stressed structural elements) in the zone of annular joints of the pipes, the residual stress values are described by the following equation:

$$\sigma_r = K_h \gamma \sigma_u^{\frac{1-\xi^2}{1-\xi^4}} \qquad (5)$$

Based on the data of the study, it was established in [4] that, as a result of summing the internal thermomechanical and external stresses from the internal pressure in the welding of a stressed metal, the residual stresses are less than in the welding of unstressed structural elements. It is also established that the process of reducing the welding voltage is practically independent of when (before or after) an external voltage was applied to the structural element. To estimate the residual stresses during welding of the overlaid elements, the following formula is derived from the analysis of summation of internal and external (active) stresses:

$$\sigma_r = K_h \gamma \sigma_u (1-\alpha_\alpha \bar{\sigma}_0^{g})^{\frac{1-\xi^2}{1-\xi^4}} \qquad (6)$$

where g and γ are constants.

In the absence of stress concentrators, residual stresses are determined by the formula:

$$\sigma_r = K_h \gamma \sigma_u (1-\bar{\sigma}_0^{g})^{\frac{1-\xi^2}{1-\xi^4}} \qquad (7)$$

For a homogeneous compound with respect to mechanical properties (K_h = 1.0):

$$\sigma_r = \gamma \sigma_u (1-\bar{\sigma}_0^{g})^{\frac{1-\xi^2}{1-\xi^4}} \qquad (8)$$

In many cases [10], it is assumed that the maximum residual stresses at the seam center reach the yield strength of the welded joint σ_u. Then for γ = 1,0 formula (8) takes the form:

$$\sigma_r = K_h\, \sigma_u(1-\alpha_\alpha \bar{\sigma}_0^{g})^{\frac{1-\xi^2}{1-\xi^4}} \qquad (9)$$

For g = 1, from formula (9) we obtain:

$$\sigma_r = K_h\, \sigma_u(1-\alpha_\alpha \bar{\sigma}_0)^{\frac{1-\xi^2}{1-\xi^4}} \qquad (10)$$

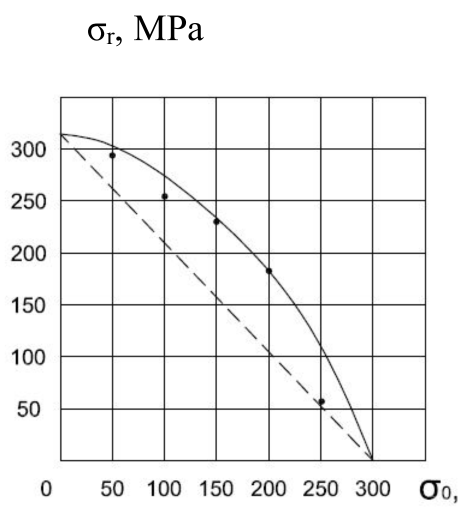
Substituting in the formula (10) $\xi = 1$ we obtain the well-known formula N.S. Oberblom [5].

Analysis of the residual stresses in the welding field σ_r, followed by an increase in the external load, shows that the decrease in residual stresses from the value $\bar{\sigma}_0$ is not directly proportional, as follows from formula (10). The formula (9) for g = 2 corresponds more precisely to the experimental data.

Consequently, the regularity of the degree of reduction of residual stresses $k = \sigma_r / \sigma_r^{max}$ of the relative stress during welding of the overlaid elements on the chimneys

$$k = 1 - \bar{\sigma}_o^{2} \qquad (11)$$

Dependence of the degree of reduction of residual stresses is shown by σ_r of the value of the relative voltage is shown in Fig. 7.



——— according to the formula (9);

- - - according to Osterblom [5];- experimental data [10].

Fig. 7. Interconnection reduction of residual stresses σost from the magnitude of the relative voltage

As a result of the study, formulas are obtained that take into account residual stresses during welding of linings on the basis of summation of internal and external (active) stresses and taking into account stress concentrators.

REFERENCES

1. Beleny E.I. Metallicheskie konstyrukzij. [Metal construction]. E.I. Beleny and staff authors. Moskow, Stroyizdat, 1986. - 560p.
2. Chimneys. Theory of Design Practice and Constructions / Edited by S.V. Satyanov. Moscow: Stroiizdat., 2001. - 150. (in Russian).
3. Metallicheskie konstyrukzij. [Metal construction]. G.S. Vedenikov and staff authors. Moskow, Stroyizdat, 1998. 758p. (in Russian).
4. Zainulin R.S. Calculations of the resource of pipeline equipment taking into account the time factor / RS. Have come, A.G. Vakhitov, O.I. Tarabarin et al. - M.: Nedra, 2003. – 50p. (in Russian).
5. Oskerblom N.O. Design and manufacturing technology of steel structures / N.O. Oskerblom, V.P. Demyantsevich, I.P. Baykov. - L.: Stroyizdat, 1963. - 602p.
6 Peterson R. Coefficients of stress concentration. - Moscow: Mir, 1977. - 302p.
7. Nikolayev G.A. Welded constructions. Strength of welded joints and deformation of structures / G.V. Nikolaev, S.A. Kurkin, V.A. Vinokourov. - M .: Higher education. Shk., 1982. – 272p..
8. Steel structures. Norms of design, manufacture and installation. DBN B.2.6-163: 2010.- К .: Ministry of Regional Development of Ukraine, 2011. – 127 p. (in Ukrainian).
9. Steel structures. Code of Regulations SP 16.13330.2011. The updated version of SNiP II-23-81 * .- M.: - Minregionrazv., RF, 2011.-172 p. (in Russian).
10. Shakhanov S.B. Defects of welded joints and methods for their elimination. - L .: Stroiizdat, 1980. - 80s.
11. Yarovoj S.N., Gorovij A.I. Reliability and viability metal chimneys compressor stations of main gas pipeline "Kremenchug-Ananiev-Chernovtsy-Bogorodchany" after a long service life. Raschet i proektirovanij metallicheskih konstrukcij [Calculation and design of steel structures]. Moskow, MSUCE, 2013. P.251-256. (in Russian).
12. Yarovoj S.M Longevity and residual life of metal chimneys, taking into account temperature and corrosion effects // Scientific Bulletin of Construction. - Kharkov: KhNUBA, KOTV ABU, 2017. -Vip. 2 (88) .- P.110-114. (in Ukrainian).
13. Gallagher J.P. The damage tolerant design hand book / J.P.Gallagher // Metals and ceramics information center, MCIC - HB - OIR, 1984.
14. EN 1991-1-4. Eurocode 1: Action on structures – Part 1-4. General actions . Wind action. / Brussels: CEN, 2002. –p.151.
15. ISO 4354: 1997. Wind action on structures / Swizerland, 1997. –p.143.

2.6. SIMPLE METHODS OF INCREASING THE ENERGY EFFICIENCY OF WINDOWS IN THE RECONSTRUCTION OF OLD BUILDINGS

Nikiforova Tetiana, Sopilniak Artem,
Radkevych Anatolii, Shevchenko Tetiana

Introduction. Considering that today energy resources are quite expensive and the prices for them are constantly growing, the building's enclosing structures should minimize the heat flow from inside the building. The enclosing structures must have resistance to heat transfer not less than the current requirements for thermal conductivity. In the construction of new building or its reconstruction, the windows should have the minimum permissible values of heat transfer resistance (for example, 0.75 (m2K)/W for the first temperature zone of Ukraine) [1, 2]. It is also necessary to take into account the fact that condensate can form on the surface of the insulating glass, and moisture can accumulate on the slopes of the window openings, leading to the destruction of the finish decoration and the appearance of mold.

Modern technologies allow producing almost hermetic windows, the quality of which is determined by the glass, fittings and profile, which is used to make the doors and frames. Thermal insulation of metal-plastic windows depends not only on the applied double-glazed windows, but also on the profile of the window unit itself, namely the cross-sectional width and the profile thickness. As for the climate of our country, a two-chamber or three-chamber profile with a special insert for thermal insulation could be effective. On practice, a 5-chamber profile with a 2-chambered double-glazed window (glass with energy saving) meet the new requirements for resistance to heat transfer.

Modern conditions of comfort and energy efficiency requirements for enclosing structures make it necessary to use new technologies and science based constructive solutions for window filling.

Objective. To increase the resistance to heat transfer for translucent structures filling of the window openings with the prevention of moisture condensation on their surface.

Main material. For enclosing translucent structures of buildings for various purposes, calculations of thermal conductivity were made using a software package «Elcut 5».

To determine the reduced heat transfer resistance for all variants of the structures, the following materials were adopted:

- material of the bearing wall - silicate brick with the thermal conductivity coefficient λ=0,76 W/(m·K) and λ=0,87 W/(m·K), for operating conditions A and B respectively [1];
- insulation made of 100% thick expanded polystyrene with a coefficient of thermal conductivity λ=0,04 W/(m·K) [1];
- window 3-chamber PVC profile - 0,63 W/(m·K) [3];
- air gap – 0,15 W/(m·K) according to Table 12 (with a width of a closed interlayer of 5-30 cm) [4] taking into account the convection and radiation;
- standard window glass has a coefficient of thermal conductivity λ = 1,0 W/(m·K) [5], but in the heat engineering calculations of light holes with a glass thickness of 0.004 m, this has almost no value in calculating the value of the heat resistance. The value of the heat resistance for glass 4 mm thick is R = 0,004/1= 0,004 (m²·K)/W. At the required value R = 0.75 (m² / K) / W, glass has no effect.

As an initial constructive solution of the enclosing structure, it was accepted that the bearing wall is made of silicate brick 510 cm thick and translucent construction is window with a single-chamber double-glazed window (4-16-4 mm) and a three-chamber window profile.

Further, several options for heat insulation of the load-bearing wall and reducing heat loss through a translucent structure (window) were considered:

- load-bearing wall of silicate brick 510 cm thick without insulation;
- load-bearing wall with the insulation of expanded polystyrene plates with a thickness of 100 mm and density ρ = 25 kg/m^3;
- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of the second window within the edge of the bearing wall, an air layer between the inner edges of the insulating glass units 100 mm thick;

- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of a second window block protruding beyond the face of the bearing wall, an air gap between the inner edges of insulating glass with a thickness of 130 mm

- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of the second window unit outside the thickness of the supporting wall in the layer of insulation, the air gap between the inner edges of insulating glass units 180 mm thick;

- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of the second window unit in the layer of insulation along the level with the outer edge of the insulation, the air gap between the inner edges of the double-glazed windows 200 mm thick;

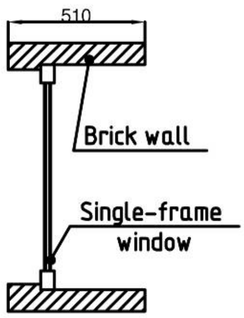
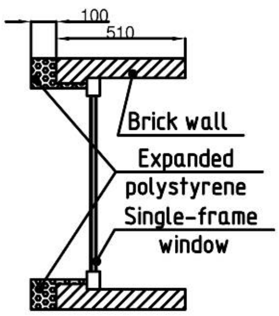
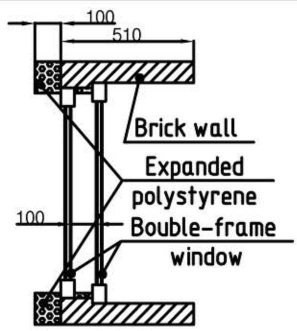
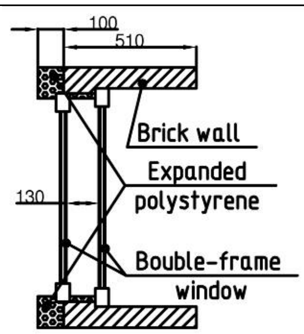
- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of the second window unit in the layer of insulation along the level with the outer edge of the insulation, and also with an addition insulation layer of expanded polystyrene plates with thickness of 50 mm and width of 100mm by perimeter of window; the air gap between the inner edges of the double-glazed windows 200 mm thick;

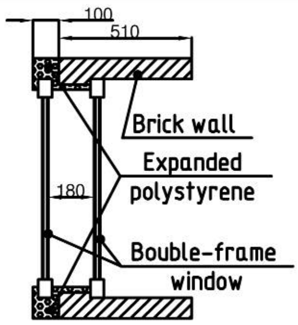
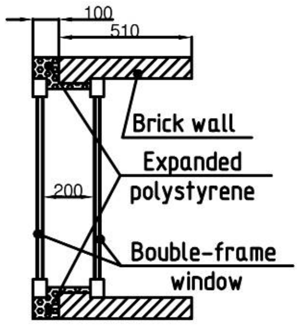
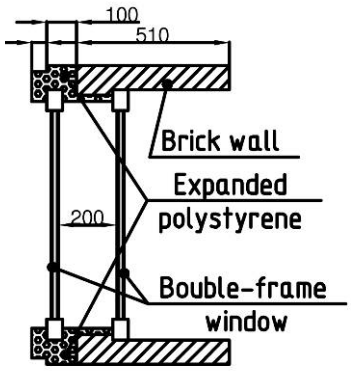
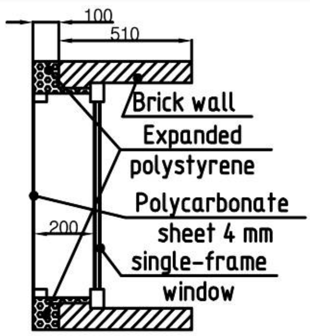
- load-bearing wall with the insulation of expanded polystyrene plates (100 mm, ρ = 25 kg/m^3) and installation of the second window block with one layer of polycarbonate in a layer of an insulation along with an its external side; the air gap between the inner edges of the double-glazed windows 235 mm thick;

Table 1 shows the schemes of constructive solutions for filling a window opening with one frame and for a variant with the installation of an additional window frame, as well as the distribution of temperature fields and the results of calculations of the reduced resistance of heat transfer obtained in the program complex «Elcut 5».

To confirm the data obtained in the program complex «Elcut 5», for the second and last version (according to Table 1) of the enclosing structure with the installation of an additional window frame with polycarbonate (4 mm), a thermal imaging was performed in the winter period at an ambient air temperature of -10 (fig. 1).

Table 1. Comparison of thermal resistance of constructive solutions translucent structures for mass application

№ п.п	Sketch of a wall cross-section with a translucent structure	Structure	Heat transfer resistance, m²•°C/W
1.		Brick wall 510 mm, single-frame window	0,46
2.		Brick wall 510 mm, single-frame window, expanded polystyrene 100 mm ρ = 25 kg/m3	0,50
3.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 100 mm	1,53
4.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 130 mm	1,84

5.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 180 mm	2,73
6.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 200 mm	3,01
7.		Brick wall 510 mm, double-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 200 mm	3,05
8.		Brick wall 510 mm, single-frame window, expanded polystyrene 100 mm ρ = 25 kg / m3, air gap 235 mm	3,15

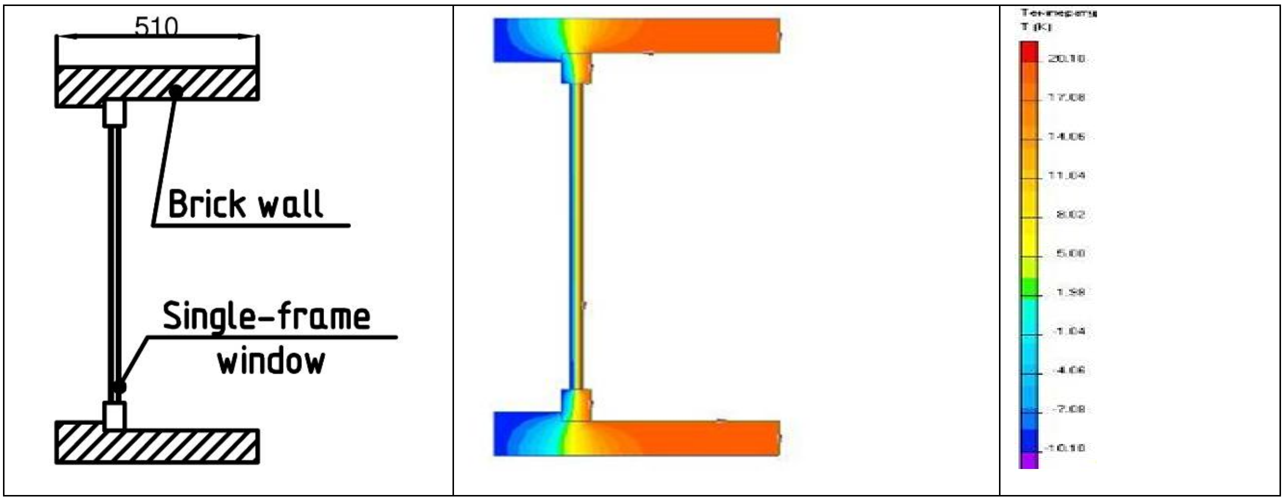


Fig.1. An example of the obtained results for the distribution of temperature fields along the thickness of the structure

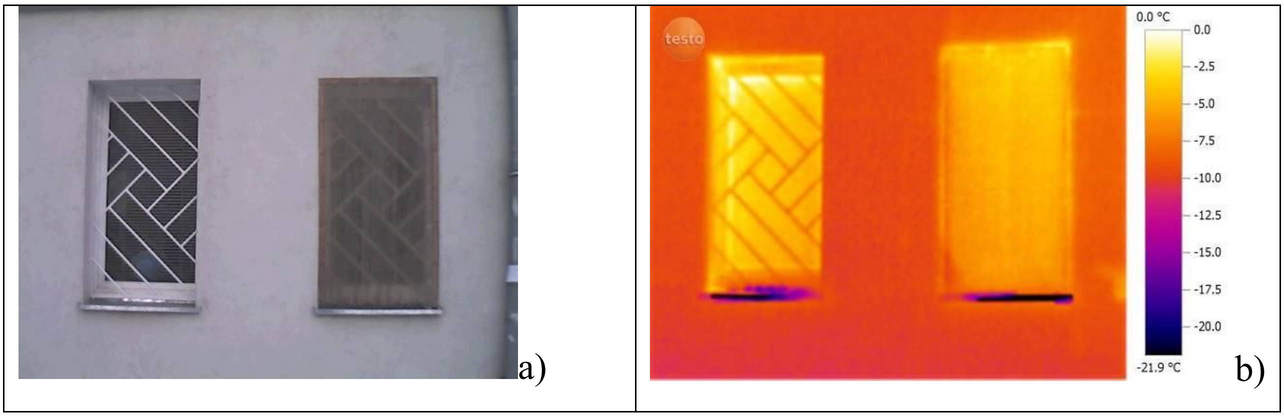


Fig. 2. a) Fragment of the enclosing structure with a single-frame window and installation of an additional window frame of polycarbonate (4 mm); b) Thermogram of the fragment of the enclosing structure with a single-frame window and the installation of the additional window frame made of polycarbonate (4 mm)

When the thermal imaging was performed, the temperature on the surface of the insulation (expanded polystyrene ρ = 25 kg / m3, 100 mm) of the bearing wall was -9 ° C. On the single-window window, in the middle part, the temperature on the surface of the glass was -3°C, and on the window (in the middle part), with an additional window frame made of polycarbonate (4 mm), the temperature on the polycarbonate surface was -6.5°C.

When performing a thermal imaging from the inside of the room (on the same fragment of the enclosing structure) for the second and last variant (according to Table 1) of the enclosing structure with the installation of an additional window frame with polycarbonate, the room air temperature was + 20 ° C, and on the surface of the bearing wall + 18.5 ° C.

In the middle part of the single-frame window the temperature on the surface of the glass was +10 °C (Fig. 3), and on the window with an additional window frame of polycarbonate the temperature was + 16 ° C (Fig. 4)

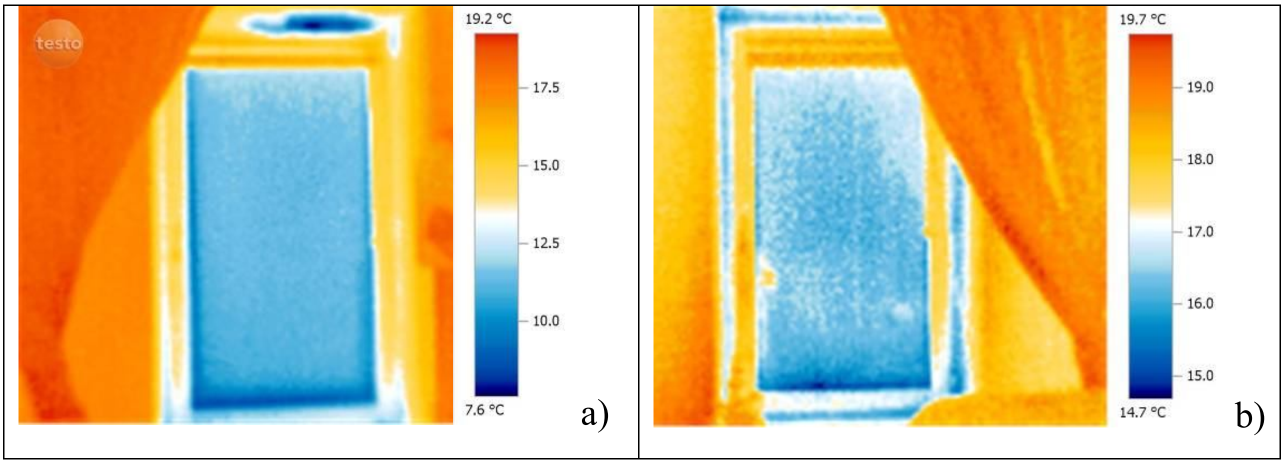


Fig. 3. Thermogram of the fragment of the enclosing structure from the inside a) with a single-frame window and b) with installation of additional window frame of polycarbonate (4 mm)

It is also worth noting that, there is completely no condensation on the window with an additional window frame made of polycarbonate, in contrast to a single-frame window where the condensate forms over the entire area of the glass unit/. Consequently, window slopes become wet and fungal formations appear in the form of black spots.

According to the obtained results of the distribution of temperature contour plots obtained in the PC "Elcut" and calculations of the heat transfer resistance (Table 1), the following conclusions can be drawn:

when the air gap between the window frames increases, the temperature contour plots become equalized to the contour plots of the bearing wall. This is due to the presence of an air gap having a small coefficient of thermal conductivity, as well as convection and radiation. Due to the phenomenon of the convention through the windows, about 30% of all heat losses occur. This effect can be minimized by installing roll blinds with a reflective coating into the air layer.

The results of the thermal imager have some differences in the calculated temperature data obtained from the PC "Elcut". This can be explained by the imperfection of the software package, as well as the error in the accuracy of the thermal imager.

Conclusions. Установка дополнительной оконной рамы для ограждающих светопрозрачных конструкций повышает сопротивление теплопередаче, снижает тепловые потери, предотвращает образование конденсата на окне и образование грибка на поверхности откосов. The installation of an additional window frame for enclosing translucent structures increases heat transfer resistance, reduces heat loss, prevents the formation of condensation on the window and the formation of fungus on the surface of slopes.

REFERENCES

1. Konstruktsiyi budinkiv i sporud. Teplova IzolyatsIya budIvel. [Construction of buildings and structures. Thermal insulation of buildings]. DBN V. 2.6-31:2016 [State standard of Ukraine V. 2.6-31:2016]. Kiev. The Ministry Of Construction Of Ukraine. 2006. 71 p. Available at: http://www.dbn.at.ua. (in Ukrainian).
2. http://servisbud2000.com.ua/n100392-novye-trebovaniya-teploprovodnosti.html.
3. BudIvelnI materIali. ProfIlI polIvInIlhloridnI dlya ogorodzhuvalnih budIvelnih konstruktsIy. ZagalnI tehnIchnI umovi. [Building materials. Sealants for enclosing structures. General technical conditions] DSTU B V.2.7-130:2007 [State standard of Ukraine V.2.7-130:2007]. Kiev. The Ministry Of Construction Of Ukraine. 2007. Available at: http://www.dbn.at.ua. (in Ukrainian).
4. Y.G. Malyavina. Teplopoteri zdaniya. Spravochnoye posobiye [Heat loss of the building. Reference Manual]. Moskov. «AVOK-PRESS». 2007. 265 p. Available at: http://www.journal.esco.co.ua/cities/2013_8/art257.pdf
5. BudIvelnI materIali. Sklo listove. TehnIchnI umovi (EN 572:2004, NEQ) [Building materials. Glass sheet. Specifications] DSTU B V. 2.7-122-2009 [State standard of Ukraine B V. 2.7-122-2009]. Kiev. The Ministry Of Construction Of Ukraine. 2010. 29 p. Available at: http://www.dbn.at.ua. (in Ukrainian).

2.7. TRUSS TOPOLOGY OPTIMIZATION AND BUCKLING

Egorov Evgen, Kucherenko Alexander

A rational constructive scheme of a structure determines both compliance with technical requirements and economic effectiveness of the project. According to [1], up to 73% of the construction cost is the cost of materials, so minimization of material consumption is one of the most important items in a design process. The basis of the optimal design is a vast family of mathematical optimization techniques.

For example, in [2] the authors solve the optimization task for trusses, plates and shells using genetic algorithms taking into account invariability, rigidity, stress. In [3] the optimization of truss-like structures is considered as a linear programming problem, and in [4, 5] it's regarded as a convex programming problem. In [6] the buckling problem is analyzed as a non-convex task. This violates the general approach to the problem and hinders the search for global optimal solution. All these papers are united by the fact that the buckling problem isn't regarded properly. Taking these facts into account it's important to consider the truss topology optimization problem and buckling as two parts of one problem.

Generally for beams with large slenderness ratios we use the Euler's formula (curve I in Figure 1):

$$\sigma_{crit} = \frac{\pi^2 EJ}{(\mu L)^2 A} = \frac{\pi^2 E}{s^2}, \qquad (1)$$

where E is a Young's modulus, J is a moment of inertia, L is a length, A is an area, μ is an effective length factor, s is a slenderness ratio. For beams with intermediate values of the slenderness ratios (line II in Figure 1) the Yasinsky's formula is used:

$$\sigma_{crit} = a - bs, \qquad (2)$$

where a and b are the coefficients. If, however, the beam is very short and has a small slenderness ratio the yield stress will be reached long before buckling can occur. This is shown as a horizontal line III in Figure 1.

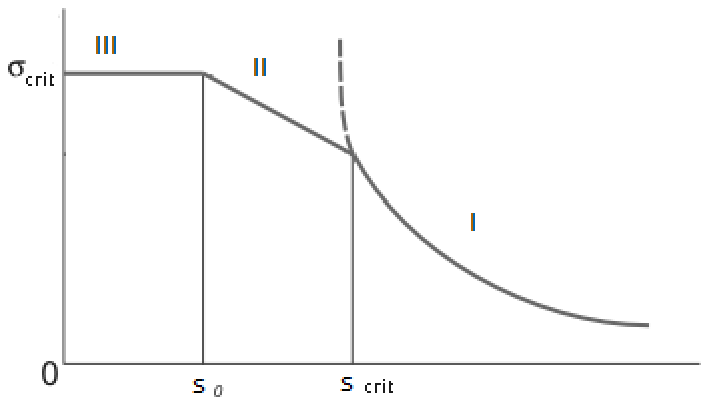


Figure 1 - Stress-slenderness ratio

The main problem with this approach is to find suitable values of μ for each slender beam. According to [7] it can vary in wide ranges. Thus, an approach based on finite element method is more suitable in this case. For each beam in a truss-like structure it is possible to compose a stiffness matrix as follows:

$$k=\begin{pmatrix}
\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 & \frac{-EA}{L} & 0 & 0 & 0 & 0 & 0 \\
 & \frac{12EI_z}{L^3} & 0 & 0 & 0 & \frac{6EI_z}{L^2} & 0 & \frac{-12EI_z}{L^3} & 0 & 0 & 0 & \frac{6EI_z}{L^2} \\
 & & \frac{12EI_y}{L^3} & 0 & \frac{-6EI_y}{L^2} & 0 & 0 & 0 & \frac{-12EI_y}{L^3} & 0 & \frac{-6EI_y}{L^2} & 0 \\
 & & & \frac{GI_x}{L} & 0 & 0 & 0 & 0 & 0 & \frac{-GI_x}{L} & 0 & 0 \\
 & & & & \frac{4EI_y}{L} & 0 & 0 & 0 & \frac{6EI_y}{L^2} & 0 & \frac{2EI_y}{L} & 0 \\
 & & & & & \frac{4EI_z}{L} & 0 & \frac{-6EI_z}{L^2} & 0 & 0 & 0 & \frac{2EI_z}{L} \\
 & & & & & & \frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
 & & & & & & & \frac{12EI_z}{L^3} & 0 & 0 & 0 & \frac{-6EI_z}{L^2} \\
 & & & Sym. & & & & & \frac{12EI_y}{L^3} & 0 & \frac{6EI_y}{L^2} & 0 \\
 & & & & & & & & & \frac{GI_x}{L} & 0 & 0 \\
 & & & & & & & & & & \frac{4EI_y}{L} & 0 \\
 & & & & & & & & & & & \frac{4EI_z}{L}
\end{pmatrix}, \qquad (3)$$

where G is a shear modulus; I_x is a polar moment; I_y, I_z are moments of inertia.

A stiffness matrix, which takes into account nonlinear effects in a beam is called geometric and has the following form:

$$k_g = f\begin{pmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 & \frac{6}{5L} & 0 & 0 & 0 & \frac{1}{10} & 0 & \frac{-6}{5L} & 0 & 0 & 0 & \frac{1}{10} \\
 & & \frac{6}{5L} & 0 & \frac{-1}{10} & 0 & 0 & 0 & \frac{-6}{5L} & 0 & \frac{-1}{10} & 0 \\
 & & & \frac{I_y+I_z}{AL} & 0 & 0 & 0 & 0 & 0 & -\frac{I_y+I_z}{AL} & 0 & 0 \\
 & & & & \frac{2L}{15} & 0 & 0 & 0 & \frac{1}{10} & 0 & \frac{-L}{30} & 0 \\
 & & & & & \frac{2L}{15} & 0 & \frac{-1}{10} & 0 & 0 & 0 & \frac{-L}{30} \\
 & & & & & & 0 & 0 & 0 & 0 & 0 & 0 \\
 & & & & & & & \frac{6}{5L} & 0 & 0 & 0 & \frac{-1}{10} \\
 & & & Sym. & & & & & \frac{6}{5L} & 0 & \frac{1}{10} & 0 \\
 & & & & & & & & & \frac{I_y+I_z}{AL} & 0 & 0 \\
 & & & & & & & & & & \frac{2L}{15} & 0 \\
 & & & & & & & & & & & \frac{2L}{15}
\end{pmatrix}. \quad (4)$$

A tangent stiffness matrix of the beam is a sum of (3) and (4):

$$k_i = k + k_g. \quad (5)$$

The matrix (5) is given in local coordinates, so it is necessary to transform it to the global ones using the transformation matrix [8]:

$$T = \begin{pmatrix} t & 0 & 0 & 0 \\ 0 & t & 0 & 0 \\ 0 & 0 & t & 0 \\ 0 & 0 & 0 & t \end{pmatrix}, \quad (6)$$

where t is a 3-by-3 matrix of direction cosines. It is written as follows:

$$t = \begin{pmatrix} C_{Xx} & C_{Yx} & C_{Zx} \\ C_{Xy} & C_{Yy} & C_{Zy} \\ C_{Xz} & C_{Yz} & C_{Zz} \end{pmatrix}, \quad (7)$$

where C_{Ab} notation represents a cosine of an angle between the global axis A and the local axis b in 3D space. With (6) the matrix (5) can be transformed as follows:

$$K_i = T^T k_i T. \quad (8)$$

Thus, for each beam of the structure its tangent stiffness matrix K_i can be composed. Then all these matrices are assembled into one global tangent stiffness matrix K of the truss. This matrix K can be decomposed as follows:

$$K = LDL^T,\qquad (9)$$

where L is a lower triangular matrix, D is a diagonal matrix. According to the [9] the structure is stable if $D_{ii}>0$ for any i.

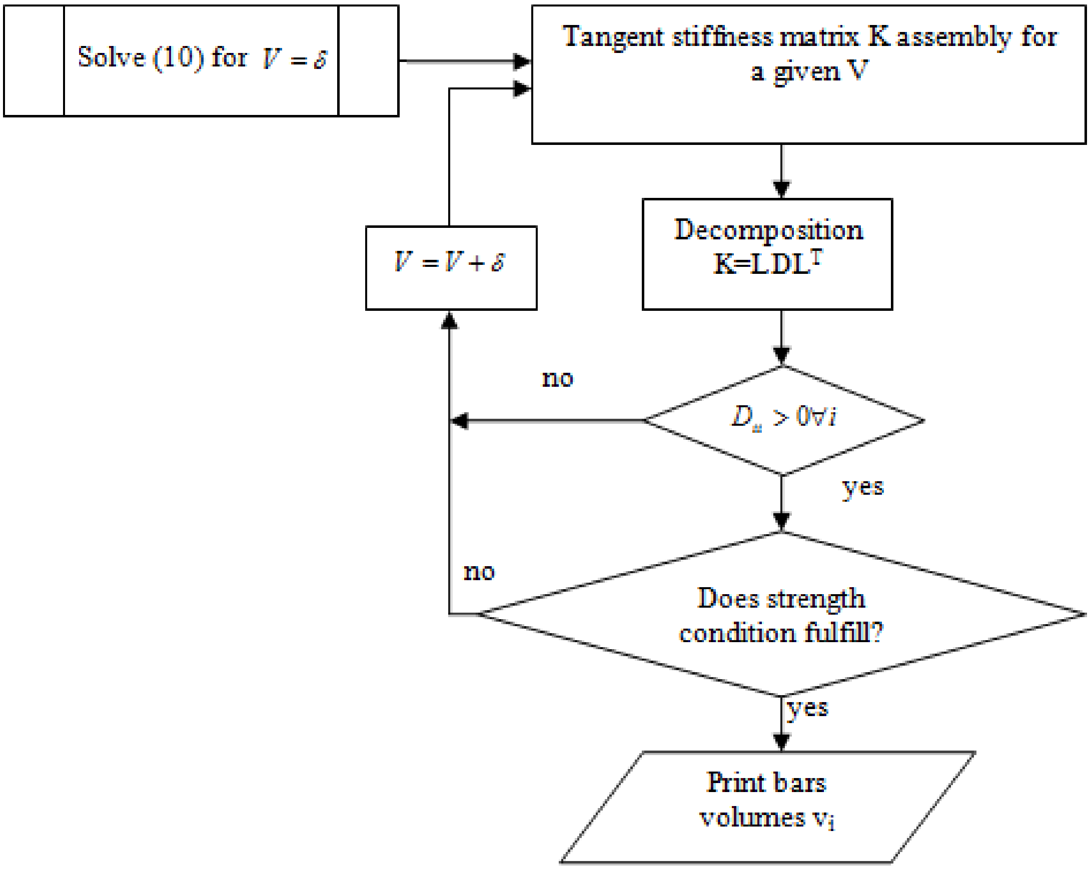


Figure 2 - General solution scheme

The problem of truss [illegible]ion can be written as a semidefinte program:

$$\begin{aligned}
&\text{minimize } W\\
&\sum_{i=1}^{m} v_i = 1\\
&v_i \geq 0 \forall i = 1..m\\
&\begin{pmatrix} W & F^T \\ F & \sum_{i=1}^{m} \frac{E_i v_i}{L_i^2} a_i a_i^T \end{pmatrix} \geq 0.
\end{aligned}\qquad (10)$$

Here W is an estimate of elastic deformation energy, v_i is a volume of the beam, m is a number of beams, F is a vector of external forces, E_i is a Young's modulus, L_i is a beam length, a_i is an i-th column of the matrix of the system A. Thus, the optimization problem is reduced to the finding of the minimum value of W. Solution of the task (10) defines the relation between the beams volumes $v_1:v_2:...:v_m$. The volume of each beam can be defined as $t_i=V\cdot v_i$.

Here we propose the general scheme for solution of the truss topology optimization problem (Figure 2). Iteratively increasing V, we can find the minimum amount of material.

Let's consider a ground structure depicted in Figure 3. For the purpose of simplicity we choose solid circular cross-section. Node 1 has a freely supported end, node 11 has a roller bearing.

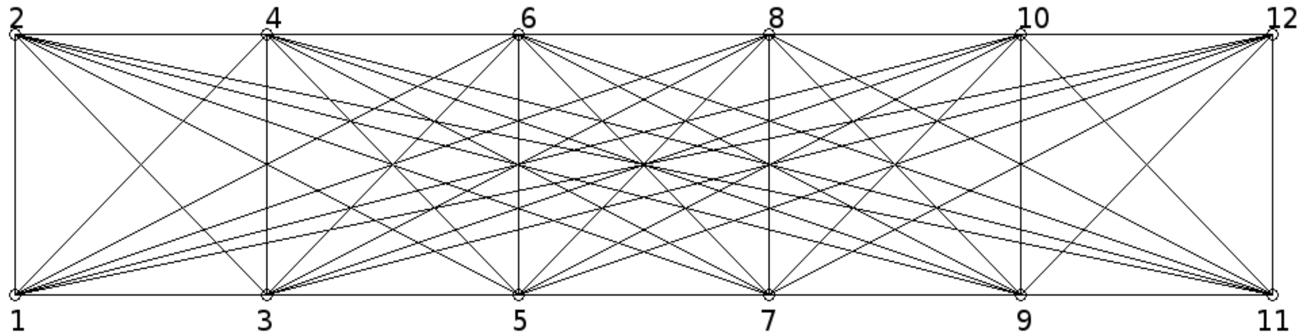


Figure 3 - Ground structure.

Load |F| has been applied to the nodes 4, 6, 8, 10. |F| varies from 10^2N to 10^7N. Solution of task (10) leads to a general topology depicted in Figure 4. In Figure 5 we can see how mass of the structure depends on the applied load |F|. For the loads larger than 5000 kN the dependence becomes linear.

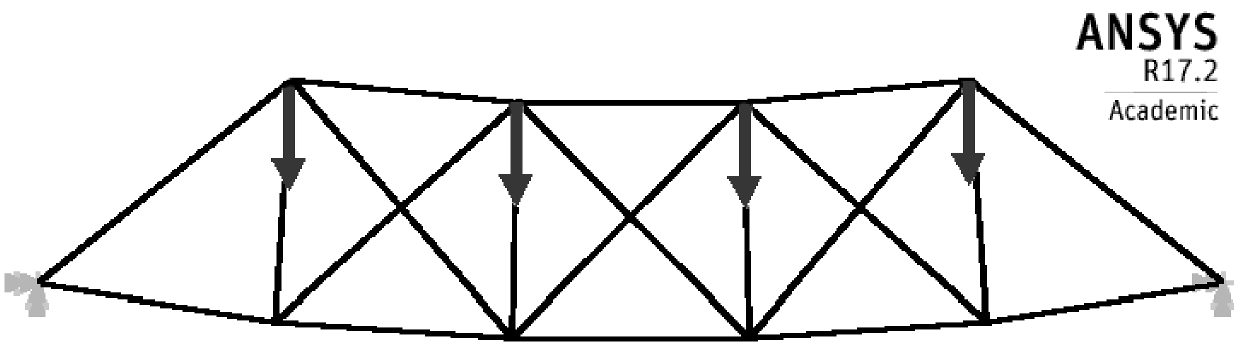


Figure 4 - Truss topology.

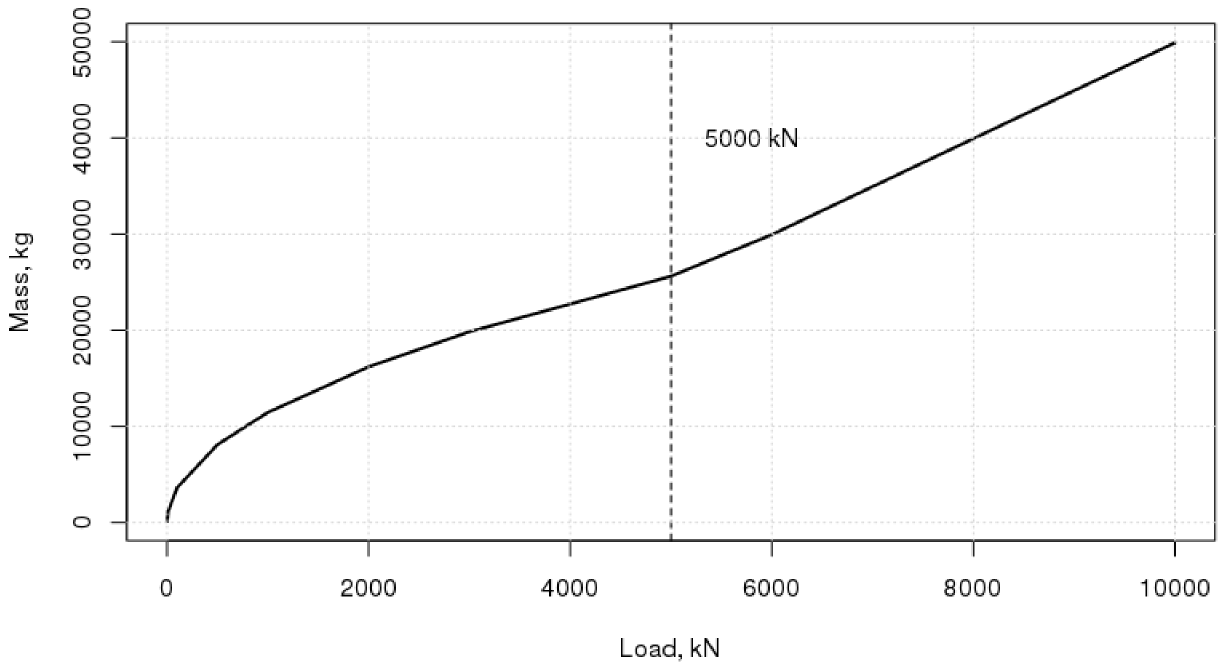


Figure 5 - Mass of structure.

The models have been exported to ANSYS Academic. Solutions of the optimization problem are consistent with the results of the models verification in ANSYS.

REFERENCES

1. Belenja E.I., Geniev A.N., Baldin V.A. Metallicheskie konstrukcii. – M.: Strojizdat, 1985. (in Russian).
2. Serpik I.N., Aleksejcev A.V., Leletko A.A. Geneticheskie algoritmy optimizacii metallicheskih stroitelnyh konstrukcij. – Brjansk: Izd-vo BGITA, 2010. (in Russian).
3. Takada T. Multiobjective optimization of truss topology by linear/sequential linear programming method. Journal of Mechanical Engineering and Automation. – 2012. - Vol. 2. – P. 585-593. (in English).
4. Ben-Tal A., Nemirovski A. Robust truss topology design via semidefinite programming. SIAM Journal on optimization. – 1997. - Vol. 7, no. 4. - P. 991-1016. (in English).
5. Yonekura K., Kanno Y. Global optimization of robust truss topology via mixed integer semidefinite programming. Optimization and Engineering. – 2010. – Vol. 11, no. 3. – P. 355-379. (in English).
6. Ben-Tal A., Jarre F., Kocvara M., Nemirovsky A., Zowe J. Optimal design of trusses under a nonconvex buckling constraint. Optimization and Engineering. – 2000. – Vol. 1, no. 2. – P. 189-213. (in English).
7. Arbabi F. Structural Analysis and Behavior. - New York: McGraw-Hill, 1991. (in English).
8. Kattan P. Matlab Guide to Finite Elements. Springer, 2008. (in English).
9. Wriggers P. Nonlinear Finite Element Methods. Springer, 2008. (in English).

2.8. SYNERGY OF VIBROECOLOGISTS, PROGRAMMERS, INVENTORS AND TESTERS OF BUILDINGS AND STRUCTURES UNDER THE EVALUATION OF THE IMPACT OF THE DYNAMICS OF STRUCTURES

Kulyabko Volodymyr, Babenko Maryna

The new (third) millennium and its initial, 21st century, from the point of view of dynamic impacts and destruction, very violently and tragically began. The powerful **earthquakes** and **tsunamis** in southeast Asia (in Indonesia, China, Japan and almost throughout the Pacific "fire belt", including Mexico, Chile, Haiti and New Zealand) have already killed hundreds of thousands of people. Europe was influenced as well by Romanian-Carpathian seismic "Vrancea Zone", with the ancient volcanoes of the Italian Sicilian region, with tsunamis on the Portuguese coasts.

Also, it should be added frequent **terrorist attacks** which used a dynamic nature of building destruction (World Trade Center in New York). The **dynamic loads** from transport and technological machines are also growing, the loads are becoming more complicated in the case of destruction of avalanche-like origin, etc. Finally, despite all this, customers and designers forced by high price of land continue to build higher and higher, in the sky, and under the ground. As a good example the project of the three kilometer (3.3 km) span of the Strait of Messina, the project has already been ready and discussed at scientific conferences. There was already an engineering competition for bridge structures with a span of 5 km. Advertising gigantomania of dreaming firms should "land" and settle with contacts with a real mixed and unstable society.

There is an actual need in design rational forest and soil massifs, which should also be considered as valuable and necessary for human life objects. There were prepared and presented a lot of materials on the dynamics and strength of these joint massifs to combat the "windshield", etc. (V.Kulyabko was a speaker at informative conferences on Wind Engineering in Warsaw-1994, Prague-1997). Very complex for the engineer and the projects of the device of green vibrocomfort housing on specially reinforced groups of trees.

General high influence of various vibration on human body was widely discussed in publications of Michael J. Griffin [1], which proves the importance of its study during the design of building according to the modern standards of sustainability.

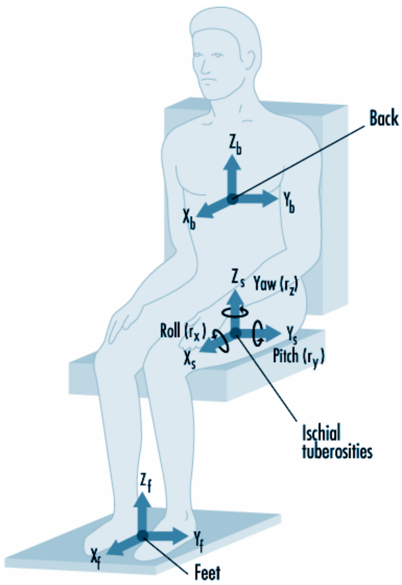


Fig. 1 Axes for measuring vibration exposures of seated persons [1]

The problems of competent creation of computational and physical (laboratory) static-dynamic non-linear models of buildings and structures that interact with complex ground masses and with different flows and currents are urgent today. As examples: with the **streams of wind**, it is more complicated to predict and realize optional design on the streets of cities with skyscrapers; with the **flows of pedestrians** on city bridges, in the norms of which there are two forbidden ranges for natural frequencies (forms of the horizontal direction of oscillations - about 1 Hz and vertical ones - about 2 Hz); finally, with flows of heterogeneous, non-linearly sprung vehicles that move along layered uneven road clothes, over a bridge, along a rail-sleeper grille. Note that threats to structures from natural seismic, near the European "Vrancea Zone", can also occur from transport, urban **and industrial seismic in dense (not green) areas**. We had to detect the strong negative effect of powerful compressors of the industrial zone on fluctuations during operations and treatment of patients in a new hospital located 2-3 km from the plant.

Today, many reserves of "construction of the future" are hidden in the fact that builders should be grouped by profession, in interdisciplinary "windows of contacts and opportunities," highlighting the following as **primary tasks**:

- generalization of the created situation and revision of **engineering norms** with specification of possible new groups of dynamic loads, impacts and situations for each region and type of structures;

- development of new computational algorithms and software complexes (SC) oriented to algorithms of **nonlinear refined calculations** available for all engineers, with detailed manuals and examples for systems with a relatively small number of degrees of freedom, and it is also desirable - with the verification of all innovations in accurate laboratory and field (natural) experiments. The fact is that the dynamic calculations of only linear systems (and today already count dozens of types of nonlinearities in the four main groups) are practically beautiful, but only commercial, pictures of the finite-element method (FEM) dynamics in many problems. Moreover, these developments should be carried out urgently: for both existing structures and for those that are still being designed. The goal is to guarantee safe, durable, comfortable and reliable design solutions, the use of widely approved protective equipment, damping devices, vibration dampers, etc .;

- Finally, the whole body of training, formation and control of retraining of civil engineers must be reviewed and ranked according to the quality of education, with the possible elimination of harm (moral and material), which can bring even one mistake of the illiterate for the tasks of engineer dynamics. Here a special role should belong to the understanding of the dynamics of modern buildings by builders, new educational projects and approaches are needed. For example, well-equipped Laboratories for the Dynamics of Constructions (LDC), in which complex questions of theory and construction practice would be comprehensive.

It should be noted that large LDCs are needed not only for educational facilitation of understanding of complex problems of physical simulation of dynamic mechanics, but also for improving the quality of engineering and scientific research of such innovations in frameworks as semi-rigid knots proposed for earthquake-proof construction.

These tasks were partially devoted to the works of the youth scientific collective "Resonance", created in the Dnieper 40 years ago [2-8], listed in this article.

Apparently, the term **"vibroecology"**, proposed by the V.Kulyabko at one of the conferences on life safety about 25 years ago, very specifically covers the above-mentioned range of tasks and separates the science of studying and ensuring sanitary norms and euro-standards for permissible vibration. In addition, the proposed types of **dynamic passports** in the method of dynamic diagnostics (MDD) for newly built or long-used buildings and structures, we began to divide into vibro-ecological, vibro-technological, etc. - depending on the purpose and life cycle of the object. Here, in our opinion, a great future for **BIM-technologies** with legal fixation in the databases of all "hidden from the project" (in acts on hidden works, when replacing during construction, etc.) and "idealized settlement" life adopted models. It is necessary to specify in the project both model structures and all parameters and combinations of loads and efforts, and "theoretical" parts of dynamic passports for each stage of construction and operation. And then, already in BIM - documents reflect all the nuances and "genetics" of structural changes after the implementation of the facility, its fires, amplifications, reconstruction, etc.

For example, there could be considered in complex: variants of models of the universal nonlinear-elastic and nonlinear-dissipative (frictional) inhomogeneous base with a non-linear-dissipative (frictional) base with unilateral ties, any inclusions of rigidity (boulder, alternation of layers of silt and sand, piles, slabs) or voids (when developing samples in mountain ranges), graphs of seasonal temperature changes, soaks, etc. variable properties and input perturbations with allowance for the delay in vectors, which can be scanned in the calculation.

To the testers of buildings and structures, see works [5, 6] and others, for the creation of a modern LDC it is necessary to expand the complexity of the work, create a parallel physical and computer (virtual) model, compare and mutually refine their data, check and supplement the results with new findings. For example, frequencies of natural oscillations of partial subsystems are important; the dependence of the logarithmic decrements of oscillations on friction types in subsystems, on the amplitudes of displacements and stresses, and so on. And in nonlinear systems, for example, with large dry friction (in supports, in the base, in the dampers), it is still necessary to refine the form of friction in the form of the envelope of free vibrations. All these data on inertial and dissipative properties are important for MDD for carrying out refined calculations of systems with new nodes, materials, and sizes. The data obtained by the testers are mandatory for fixing in models and dynamic passports in BIM-technology documents. We note that early obtaining, for example, of natural frequencies and shapes both in experiments and at the beginning of the design of an object, allows the engineer or architect to more quickly form the initial rational parameters and structure of the structure without his detailed calculations on the limiting states. This is the essence of the **method** of **dynamic shaping** (**MDS**).

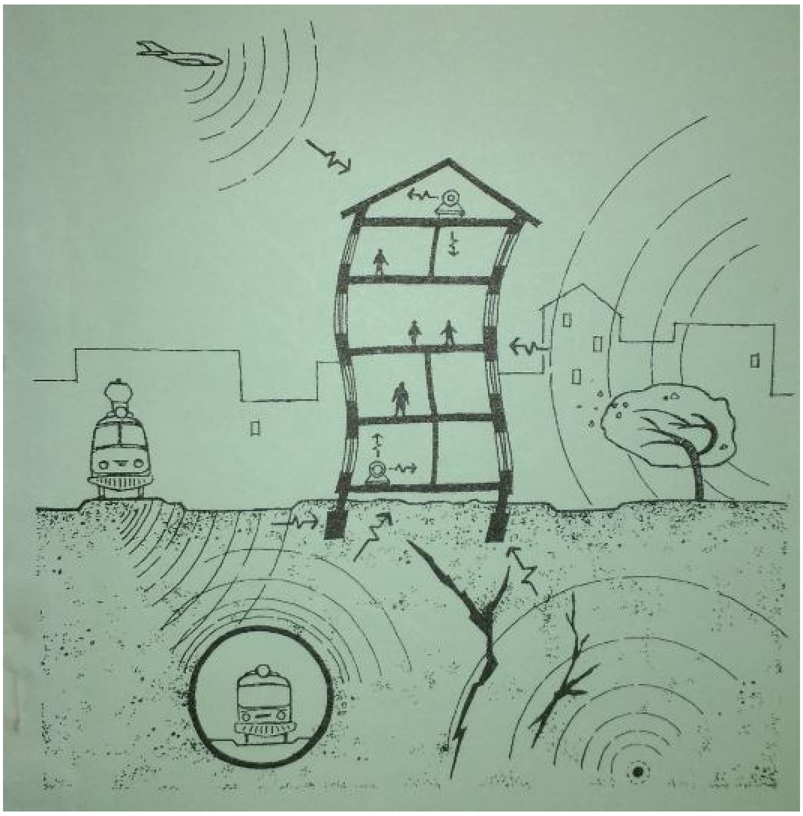


Fig.2 Conception of vibroecology study

Finally, if the algorithms of nonlinear static-dynamic (namely, simultaneous ones, there must be calculations of non-linear systems that do not obey the superposition principle) calculations are defined, then the **programmer-builders** should try the shuttle method to solve problems from simple to complex ones, reconciling with experiments.

In connection with the above, the inventors can start working on new solutions without inventing any innovation, "from the ceiling," namely, according to detailed calculations and experiments that revealed all the shortcomings of the structure. Such work fully corresponds to the **method of dynamic constructing** (MDC), when it is necessary to find, for example, the place and direction of the most effective installation of several Tuned Mass Dampers (TMD).

Conclusions.

1. It is necessary, on the one hand, to take into account the heterogeneity of materials and the element base of building objects, the continuous growth of their sizes (and, as seismologists say, people are killed not by earthquakes, but by buildings), the growth of speeds and capacities of machinery and equipment. But, on the other hand, it is also necessary to take into account the growth of sanitary requirements of customers and consumers of buildings to their comfort and manufacturability. Therefore, maximum cohesion and high professionalism of builders of different professions and different structures are appropriate. This cohesion and continuous training and retraining of specialists can be provided by organizations in the form of separate auxiliary firms, centers, associations and other forms of specialists engaged in perspective design, calculations, design, surveys and diagnostics of the technical condition of structures.

2. It is highly desirable to work on the development of the LDC networks involved in the theory and practice of experimental works on complex dynamic testing of structures, as well as developing the test profession, the dynamic measurement technique and the compiler of dynamic specialized passports of

structures and structures, documents for BIM-technologies. (Similar in the Union were regular brigades at the stations of the engineering-seismic service of the ISS). Established at universities, schools, factories, and large construction corporations, LDC can solve many problems of the national economy, including vocational training and narrowly specialized scientific growth. They can evaluate the usual "harm" from the action of specific dynamic disturbances on the structure, and derive "benefits" from new uses, for example, dynamic characteristics in monitoring and certification of the facility, MDS, MDC and MDD methods.

3. The experience accumulated in the **Resonance collective** shows tremendous reserves in improving the pedagogical orientation and professional motivation in the forms of transferring the education of talented youth. We need a careful individual approach to each, respectful time savings and a rigorous analysis of sometimes empty time spent in the educational process. Our team has prepared and defended several doctoral and master's dissertations on the dynamics of buildings, bridges, masts, towers. Published articles and books in many countries in different languages, made presentations at various scientific conferences.

Great benefit will also be given to the **joint implementation of dynamic laboratory** and full-scale tests, the creation of international types of dynamic passports of structures and buildings, standards for dynamic monitoring and diagnostics of the technical condition of structures and structures with effective damage search at the pre-emergency facility.

4. Closer inter-disciplinary international cooperation in the mentioned field will improve the general fundamental knowledge in proposed new discipline to study in the context of sustainable development – vibroecology.

REFERENCES

1. Michael J. Griffin Vibration is oscillatory motion. Access: http://www.ilocis.org/documents/chpt50e.htm
2. M.Kazakevich, V.Kulyabko. Introduction to vibroecology of buildings and structures. Dnepropetrovsk: PSACEA, 1996. - 200 pp.
3. V.V. Kulyabko. The dynamics of structures - the past, the present and the future (part 1). Monograph. LAP: LAMBERT Academic Publishing, Germany. - 2014. - 172 pp.
4. V.Kulyabko, D.Yaroshenko, A.Necitailo. Zones of condensation of natural frequencies on the spectra of beams, frames and trusses with the same type of partial subsystems in models. Building Constructions: Interdepartmental Sciences. Tech. col. sciences works (construction) / Construction in seismic areas of Ukraine, # 82 Kiev, DP NDIBK, 2015. - P. 132-141.
5. V.Kulyabko. Problems of protection of structures against dynamic impacts and the need to expand cooperation in the field of dynamics. Building Constructions: Interdepartmental Sciences. Tech. col. sciences works (construction) / Construction in seismic areas of Ukraine, # 82. Kyiv, NDIBK DP, 2015.- P. 328-334.
6. V.Kulyabko, V.Chaban, A.Makarov. Inspection and dynamic certification of structures as a tool for searching for damage to load-bearing structures. Building Constructions: Interdepartmental Sciences. Tech. col. sciences works (construction)/ Construction in seismic areas of Ukraine, # 82. Kyiv, NDIBK DP, 2015.- P. 484-492.
7. V.Kulyabko. On the relations between nonlinear dynamics, norms, calculations, tests and design of seismic objects. Collection of abstracts of the International scientific and technical category "Problems of theory and practice of seism resistance constructions", Odessa, 2016. - P. 62-68. ISBN 978-617-7195-27-5.
8. K.Eremin, V.Raizer, V.Telichenko, V.Kulyabko andother. Safety assessment of existing buildings and structures. Monography. - Stockholm, Sweden: FSV Construction, 2016. – 268 pp.

2.9. THE MODERN STEEL AND CONCRETE COMPOSITE CABLE SPACE FRAMES

Storozhenko Leonid, Gasii Grygorii

Development of infrastructure of cities needs modernization, changes or rebuild existing structures and construction modern and original buildings. Structures that completely satisfy the demanding requirements of buildings are combination of steel space trusses, steel cables or bars and slabs that used for not only cover or protect from aggressive external factors, rain, snow and other atmospheric influences but also used as bearing element.

These composite structures were designed with the participation of the author at the Department of structures from a metal, wood and plastics of the Poltava National Technical Yuri Kondratyuk University (Poltava city, Ukraine) and were patented. They are called The Steel and Concrete Composite Cable Space Frames.

The purpose of the study is to present the new kind of spatial composite structure made from modern and strength materials for civil construction in particular to cover halls, hangars for aircraft and other vehicles, garages for a large machinery, large-span buildings and structures of airports etc.

Novelty of the steel and concrete composite cable space frame lies in effective application properties of materials [1].

The steel and concrete composite cable space frame are assembled on construction site from steel-concrete space units (Fig. 1) and the bottom chords. The structural members are routinely joined at node 1 and node 2 by designed by author bolted connections [2], but sometimes in specific cases can be joined by welded connections.

Besides, node 1 and node 2 can have different designs depend on the forces that appeared in the structural members [2]. Choice of a connection type (node 1 and node 2) are routinely depend on buildings function, their span and shape, but preference is given to bolted connections, because they are easier in assembling and they are able to carry the high loads that typically appear in structural members of civil structures. The steel and concrete composite cable space frame can have various shapes and contours. Curvature of the structure is achieved by changing length of the bottom chord.

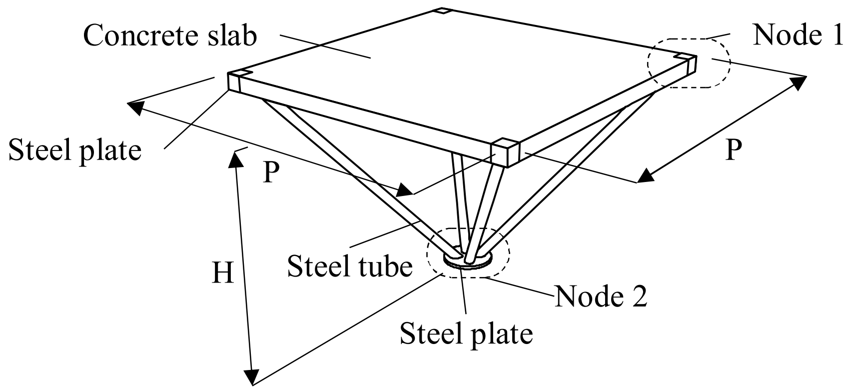


Fig. 1. The steel-concrete space units of the steel and concrete composite cable space frame

The steel-concrete space units are used for assembly various structures including flat double-layer grids, single-span shells and other [3, 4]. Distances that are covered with these structures reaches 100 m. In general, the curvature of the steel and concrete composite cable space frame depends on constrains.

There are a need to find effective structural systems including shells in today's conditions of the development of scientific and technological advances and the growth of social needs. The main requirements imposed on shells or its parts except reliability and the required bearing capacity are an architectural view, aesthetics, ergonomics and high indicators of efficiency.

Use of reliable and modern materials to search and designing of the new structural concept is an important issue. Steels, modern concretes with various fillers and composites belong to the materials that meet the stated requirements.

The effectiveness of the developed structures depends on the usage of these materials and their conditions of behavior it means that materials need to be under pressure of the forces, which they resistance well this means steel needs to use in stretched or compressed elements and concrete needs to use in compressed.

Considering this, the steel and concrete composite cable space frame is promising direction of building structures.

In [5] are proposed and developed kinds the steel and concrete composite cable space shells with the release of their main advantages and design features. In result of studied, the new efficient structures of shells that appointment for covering large-span buildings and areas were proposed.

Developed steel and concrete composite cable space shells appointment for industrial and civil construction. Applications developed designs for the construction of large-span covering objects provides a significant economic benefit through the efficient use of materials [6].

There is a problem of an excessive laboriousness and materials consumption, which appears in consequence of does not rational using of materials in construction. These factors have direct impact on the overall cost and duration implementation of the project. That is why there is a need in new constructions with structural concepts, which largely make it possible to save materials and reduce complexity of construction. These structures are the steel and concrete composite cable space frame. Steel-concrete composite structure was used for creating the new construction because this material is reliable, has studied well and is used very widely in various fields of construction [7, 8]. The essence of the steel and concrete composite cable space frame lies in rational and efficient use of materials and the behavior of structural elements.

Results of previous studies show that the steel and concrete composite cable space frame combine the advantages of space frame, reinforced concrete and cable structures [9]. The effectiveness of structural concept and optimal geometric dimensions have been found [10]. The steel and concrete composite cable space frame are reliable and have nice aesthetic appearance due to original spatial shapes and outlines. Therefore, it is necessary to prove the effectiveness of the steel and concrete composite cable space frame to increase interest and implementation them in the real sector of the construction.

Production of steel-concrete space units can be performed in the plants that produce steel building structures, and other plants that have the equipment for processing steel and concrete casting of products. Technologies of processing, assembly, welding, loading and unloading of steel structural member of the composite steel and concrete grid-cable constructions are similar to the technology of production of conventional steel structures and concrete structures. Manufacturing technology of the steel and concrete composite cable space frame is divided into two separate processes: fabrication of a steel lattice (frame) and the making of slab.

Construction of the steel and concrete composite cable space frame is perform by the methods described in [11]. During design of steel and concrete composite cable space frame there is a task to get rid of the disadvantages of steel and concrete elements. The question concerning the choice of strength grade of concrete, steel tubes grade, acceptance of reinforcement ratio is of great importance [11].

REFERENCES

1. Gasii G. M. Types of steel and concrete composite cable space frames / G. M. Gasii // Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport. – 2016. – № 6 (66). – P. 158-165.
2. Gasii G. M. The flat double-layer grid-cable steel-concrete composite / G. M. Gasii // Proceedings of the METNET Seminar 2016 in Castellon. – Hämeenlinna, Finland: HAMK University of Applied Sciences, 2016. – P. 56-62.
3. Gasii G. M. The main points of form finding and designing structure systems from the steel-concrete grid-cable composite constructions / G. M. Gasii // Construction, materials science, mechanical engineering. – 2016. – № 87 – P. 48-53.
4. Storozhenko L. I. The new composite designs for mine tunnel support / L. I. Storozhenko, H. M. Hasii // Scientific Bulletin of National Mining University. – 2015. – № 4. – P. 28-34.
5. Storozhenko L. I. The features of structural concept and designing of the full-length experimental module of the composite steel and concrete grid-cable roof / L. I. Storozhenko, G. M. Gasii // Academic journal. Industrial Machine Building, Civil Engineering. – 2016. – № 1 (46) . – P. 51-59.
6. Gasii G. M. Comparative characteristics of the spatial grid-cable steel-concrete composite slab / G. M. Gasii // Academic Journal of Lviv Polytechnic National University. Series «Theory and Building practice». – 2016. – № 844. – P. 260-265.
7. Oehlers D. J. Composite Steel and Concrete Structures: Fundamental Behaviour / D. J. Oehlers, M. A. Bradford. – Elsevier, 2013. – 588 p.
8. Johnson R. P. Composite structures of steel and concrete: beams, slabs, columns, and frames for buildings / R. P. Johnson. – John Wiley & Sons, 2008. – 252 p.
9. Storozhenko L. I. The new composite and space grid cable-stayed constructions / L. I. Storozhenko, G. M. Gasii, S. A. Gapchenko // Academic journal. Industrial Machine Building, Civil Engineering. – 2014. – № 1 (40). – P. 91-96.
10. Gasii G. M. Experimental studies of structural-guy rope coverings / G. M. Gasii // Academic journal. Industrial Machine Building, Civil Engineering. – 2014. – № 3 (42). – P. 47-51.
11. Storozhenko L. I. The composite steel and concrete grid-cable space structures: Monograph / L. I. Storozhenko, G. M. Gasii, S. A. Gapchenko. – Poltava: «ASMI», 2015. – 218 p.

2.10. DEPENDENCE OF NORMAL DEFORMATIONS ON SHEAR STRINS UNDER THE CONDITION OF PLASTICITY OF TRESCA-SAINT-VENANT

Davydov Igor, Pogrebnyak Nikolai, Kovtun Kyrylo

Green buildings expands and complements the classical methods of calculation and design of structures. The purpose of green buildings is to reduce the level of consumption of energy and material resources throughout the life cycle of the building, including design and construction, overhaul, reconstruction, demolition. It is therefore important to improve the methods for calculating the design. This allows to ensure the durability, safety and rational use of materials in the concept of architectural and constructive-technological systems for green buildings [1].

In the mechanics of a deformed solid body and in the resistance of materials, the basic simplest forms of the stress-strain state of a continuous medium are: pure stretching, pure compression and pure shear [2]. In pure tension (compression), in addition to longitudinal deformations (deformations along the uniaxial load direction), transverse deformations (deformations normal to the load axis) also occur. With pure shear, normal deformations to shear planes are not taken into account. However, the Inelastic Shear Research, strains normal to shear planes occur in materials with different resistance to stretching and compression. The solution of problems of this type in the mechanics of a deformed solid body and in the resistance of materials is not provided [3,4,6-8]. Based on the methods and conditions of the mechanics of the deformed solid body and the resistance of materials, establish the dependence of the normal strains under pure shear as a function of shear deformations [5]. Goal and the task - based on the methods and conditions of the mechanics of the deformed solid body and the resistance of materials, establish the dependence of the normal strains under pure shear as a function of shear deformations.

We consider a pure shear of the elementary cube near the material point subjected to a shear in one plane (plane stressed-deformed state). Element (cube) material is a continuous medium with different inelastic (plastic) properties under tension and compression. Elasticity limit under the tension is higher or lower than elasticity limit under the compression. Plasticity modulus is unchanged (equal) for both tension and compression cases. Character rule for tension and compression: tension – positive; compression – negative. Pure shear conditions: only the tangential stresses on the faces of the element, normal stresses are absent (normal stresses on the shaer planes are zero); tangential stresses and, accordingly, strain displacements on mutually perpendicular planes are equal in values and opposite directed (symmetry of displacement); the volume of the element does not change (relative volume change is zero), only the shape changes, the displacement measurement is the shift angle, that is, the relative shift; flat edges of the element remain flat and pairwise parallel after the deformation (the distribution of deformations along the edges is linear).

The analysis of the stress-strain state of the elementary cube near the material point, was carried out on the basis of the methods and conditions of the mechanics of a deformable solid and material resistance [2-8]. The condition of plasticity of Tresca - Saint-Venant was used in the analysis. The diagram of the mechanical state of the material is idealized to trilinear. The scheme of element deformations, stresses and their components are presented on are presented on fig. 1.

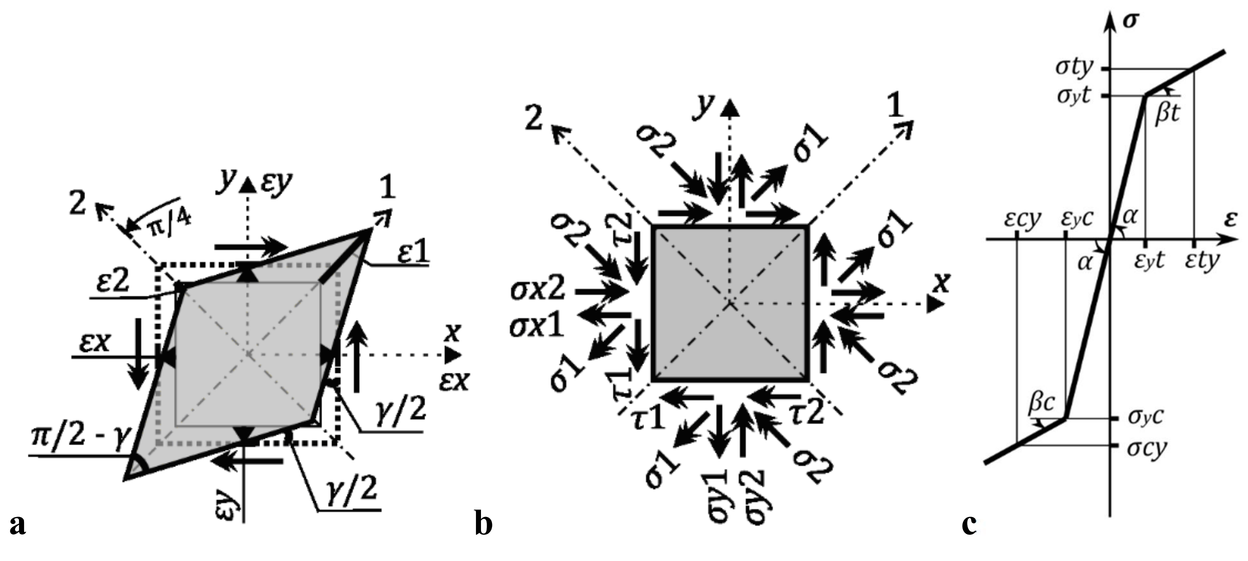


Fig. 1. Scheme of element deformations and stresses under pure shear: a – deformations and their components; b– stresses and their components; diagram of mechanical state of the material

The main mechanical characteristics of the material are presented in table 1. In researches, for the generalization and independence of mechanical characteristics, we're using reduced deformation characteristics of the material and reduced stresses.

The method of reducing the mechanical characteristics of materials and their application in calculations used in accordance with [5]. Reduced mechanical characteristics of material for compactness are given in the table form, see table 2.

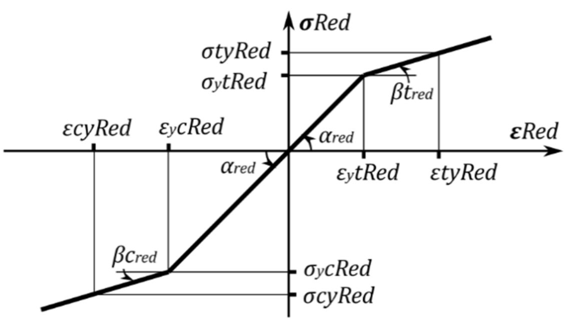
Table 1. Mechanical characteristics of the material

Characteristics of stresses	Deformation characteristics
Name, unit of measurement: designation and expressions	
stresses, (MPa): σ at elasticity limit under tension: $\sigma_y t$ at elasticity limit under compression: $\sigma_y c$ average along elasticity limits: $\sigma_y tc = \frac{\sigma_y t - \sigma_y c}{2}$ beyond elasticity limit under tension: σty beyond elastisity limit compression: σcy stress growth beyond elasticity limits under tension: $\Delta\sigma ty = \sigma ty - \sigma_y t$ stress growth beyond elasticity limits under compression: $\Delta\sigma cy = \sigma cy - \sigma_y c$ Tensions depending on relative deformations: $\sigma = \begin{cases} E * \left((1 - E_h c) * \varepsilon_y c + E_h c * \varepsilon\right), \varepsilon < \varepsilon_y c \\ E * \varepsilon, \varepsilon_y c \leq \varepsilon \leq \varepsilon_y t \\ E * \left((1 - E_h t) * \varepsilon_y t + E_h t * \varepsilon\right), \varepsilon_y t < \varepsilon \end{cases}$	Plasticity modulus, MPa: $E = \tan\alpha$ Relative deformations (no unit): ε at elasticity limit under tension: $\varepsilon_y t = \frac{\sigma_y t}{E}$ at elasticity limit under compression: $\varepsilon_y c = \frac{\sigma_y c}{E}$ average along elasticity limits: $\varepsilon_y tc = \frac{\varepsilon_y t - \varepsilon_y c}{2} = \frac{\sigma_y t - \sigma_y c}{2 * E} = \frac{\sigma_y tc}{E}$ beyond elastisity limit under tension: εty beyond elastisity limit compression: εcy relative deformation growth beyond elasticity limits under tension: $\Delta\varepsilon ty = \varepsilon ty - \varepsilon_y t$ relative deformation growth beyond elasticity limits under compression: $\Delta\varepsilon cy = \varepsilon cy - \varepsilon_y c$ Characteristic of strengthening beyond elasticity when stretching $E_h t = \tan\beta t = \frac{\Delta\sigma ty}{\Delta\varepsilon ty}, 0 \leq E_h t \leq E$ Characteristic of strengthening beyond elasticity under compression $E_h c = \tan\beta c = \frac{\Delta\sigma cy}{\Delta\varepsilon cy}, 0 \leq E_h c \leq E.$

Reduced stresses, depending on reduced deformations are described by the function (their designations and names are given in table 2):

$$\sigma Red = f(\varepsilon Red) = \begin{cases} (1 - E_h cRed) * \varepsilon_y cRed + E_h cRed * \varepsilon Red, & \varepsilon Red < \varepsilon_y cRed \\ \varepsilon Red, & \varepsilon_y cRed \leq \varepsilon Red \leq \varepsilon_y tRed \\ (1 - E_h tRed) * \varepsilon_y tRed + E_h tRed * \varepsilon Red, & \varepsilon_y tRed < \varepsilon Red \end{cases} . \quad (1)$$

Table 2. Reduced mechanical characteristics of the material

Characteristics of stresses	Deformation characteristics
Name, unit of measurement: designation and expressions	
reduced stresses (no unit): σRed at elasticity limit under tension: $\sigma_y tRed = \frac{\sigma_y t}{\sigma_y tc}$ at elasticity limit under compression: $\sigma_y cRed = \frac{\sigma_y c}{\sigma_y tc}$ average along elasticity limits: $\sigma_y tcRed = \frac{\sigma_y tRed - \sigma_y cRed}{2} = 1$ beyond elasticity limit under tension: $\sigma tyRed$ beyond elasticity limit under compression: $\sigma cyRed$ reduced stresses growth beyond elasticity limits under tension: $\Delta\sigma tyRed = \sigma tyRed - \sigma_y tRed$ Reduced stresses growth beyond elasticity limits under compression: $\Delta\sigma cyRed = \sigma cyRed - \sigma_y cRed$ Reduced mechanical state of material diagram  	reduced stresses (no unit): εRed at elasticity limit under tension: $\varepsilon_y tRed = \frac{\varepsilon_y t}{\varepsilon_y tc}$ at elasticity limit under compression: $\varepsilon_y cRed = \frac{\varepsilon_y c}{\varepsilon_y tc}$ average along elasticity limits: $\varepsilon_y tcRed = \frac{\varepsilon_y tRed - \varepsilon_y cRed}{2} = 1$ beyond elasticity limit under tension: $\varepsilon tyRed$ beyond elasticity limit under compression: $\varepsilon cyRed$ average along elasticity limits: $\Delta\varepsilon tyRed = \varepsilon tyRed - \varepsilon_y tRed$ Reduced stresses growth beyond elasticity limits: $\Delta\varepsilon cyRed = \varepsilon cyRed - \varepsilon_y cRed$ Reduced plasticity modulus, (no unit): $E_{red} = \tan(\alpha_{red}) = \frac{\sigma_y tcRed}{\varepsilon_y tcRed} = 1$ Reduced hardening characteristic beyond elasticity limits under tension, (no unit): $E_h tRed = \tan(\beta t_{red}) = \frac{\Delta\sigma tyRed}{\Delta\varepsilon tyRed} = \frac{E_h t}{E}$ $0 \le E_h tRed \le 1$ Reduced hardening characteristic beyond elasticity limits under compression, (no unit): $E_h cRed = \tan(\beta c_{red}) = \frac{\Delta\sigma cyRed}{\Delta\varepsilon cyRed} = \frac{E_h c}{E}$ $0 \le E_h cRed \le 1$

For derivation of dependence of normal reduced deformations from reduced shear strins shear is divided to components. Scheme of elements deformation, stress and their components are analogous to fig. 1, where to each designation «Red» is added to show that its reduced. Reduced shear strins and thier components are given in Table 3.

Table 3. Reduced shear strins and their components

Name, functions and expressions
Main reduced deformations:
in the direction of the main axis 1
$\varepsilon 1Red = \left(\frac{\varepsilon xRed+\varepsilon yRed}{2}\right) + \sqrt{\left(\frac{\varepsilon xRed\text{-}\varepsilon yRed}{2}\right)^2 + \left(\frac{\gamma Red}{2}\right)^2}$, (3.1)
in the direction of the main axis 2
$\varepsilon 2Red = \left(\frac{\varepsilon xRed+\varepsilon yRed}{2}\right) - \sqrt{\left(\frac{\varepsilon xRed\text{-}\varepsilon yRed}{2}\right)^2 + \left(\frac{\gamma Red}{2}\right)^2}$. (3.2)
Position of the main axes relatively to the "x" axis:
Double-angle tangent $\tan(2\theta)_x = \frac{\gamma Red}{\varepsilon xRed\text{-}\varepsilon yRed}$, (3.3)
Double-angle cosine $\cos(2\theta)_x = \frac{\varepsilon 1Red\text{-}\varepsilon 1Red}{\sqrt{(\varepsilon 1Red\text{-}\varepsilon 1Red)^2+(\gamma Red)^2}}$, (3.4)
Double-angle sinus $\sin(2\theta)_x = \frac{\gamma Red}{\sqrt{(\varepsilon 1Red\text{-}\varepsilon 1Red)^2+(\gamma Red)^2}}$. (3.5)
Reduced shear strins and their position relatively to main axis:
the largest (maximal), in accordance with the plasticity conditions of Tresca - Saint-Venan
$\gamma_{max}Red = \varepsilon 1Red\text{-}\varepsilon 2Red = \sqrt{(\varepsilon 1Red\text{-}\varepsilon 2Red)^2 + (\gamma Red)^2}$, (3.6)
direction cosine relative to the main axis 1 $\cos(\varphi 1) = \frac{\varepsilon 1Red}{\gamma_{max}Red}$, (3.7)
direction cosine relative to the main axis 2 $\cos(\varphi 2) = \frac{\varepsilon 2Red}{\gamma_{max}Red}$, (3.8)
symmetry condition for normal deformations $\varepsilon xRed = \varepsilon yRed$. (3.9)

For derivation of dependence of normal reduced deformations from reduced shear strins shear is divided to components. Scheme of elements deformation, stress and their components are analogous to fig. 1, where to each designation «Red» is added to show that its reduced. Reduced shear strins and their components are given in table 3. Next we perform analysis under its 3 main conditions: position of the main axes; conditions of plasticity both in terms of stresses and deformations; satisfaction of pure shear basic condtion - the normal stresses on the faces of the element are zero (normal stresses are absent). Main axis positions are determined by relation (3.3), see table 3. As is known, under the pure shear tilt angle of main axis θ equals $\frac{\pi}{4}$, and $\tan(2\theta)$ equals infinity. This condition can be fulfilled when normal deformations along «x» and «y» axes are equal $\varepsilon yRed = \varepsilon xRed$. Based on this condition it can be assert that normal deformations under pure shear are equal both in value and direction sign. Similarly to pure shear condition, we can formulate next condition concerning symmetry. Normal deformations on mutually perpendicular shear planes are symmetrical relatively to main shear axes both in value and direction.

Plasticity condition (limit) is determined from elasticity condition of Tresca – Saint-Venant $\left(\frac{\sigma 1-\sigma 2}{2}=\sigma_T\right)$. Using reduced stresses this condition will be written in the following: $\frac{\sigma_y tRed-\sigma_y cRed}{2}=1$, where: σ_ytRed and $\sigma_y cRed$ – reduced stresses at elasticity limits under tension and compression respectively, see table 2. Taking into account that reduced plasticity modulus equals one (see table 2) plasticity condition for reduced deformations will be presented in the following form: $\varepsilon_y tRed-\varepsilon_y tRed=2$, where: ε_ytRed and $\varepsilon_y cRed$ – reduced deformations at plasticity limits under tension and compression respectively, see table 2. In our researches plasticity condition have the following form:

$$\varepsilon 1\mathrm{RedLimElast}\text{-}\varepsilon 2\mathrm{RedLimElast}=2, \tag{2}$$

where: ε1RedLimElast – elastic deformation limit under tension

$$\varepsilon 1\mathrm{RedLimElast}=\varepsilon_y\mathrm{tRed}, \tag{3}$$

ε2RedLimElast – elastic deformation limit under compression

$$\varepsilon 2\mathrm{RedLimElast}=\varepsilon_y\mathrm{cRed}, \tag{4}$$

The largest (maximum) stresses in a shear are determined by substituting into (1) the reduced deformations by the expression (3.6), see table 3, and the limits of elastic deformations according to equations (3) and (4). Stresses under shear and their components are summarized in table 4. Proceeding from pure shears basic condition (normal stresses are absent, that is, internal efforts are balanced) total stresses along the «x» axis determined by (4.10) equal to zero. Performing successive calculations of deformations for Table 3, taking into account symmetry of deformations ($\varepsilon yRed=\varepsilon xRed$), and, respectively, the stresses in table 4 we get the following equation:

$$\begin{aligned}&\left(2*\varepsilon xRed+\sqrt{(\gamma Red)^2}\right)*\\&\left(\begin{cases}\sqrt{(\gamma Red)^2}, & \sqrt{(\gamma Red)^2}<\varepsilon_y tRed\\(1-E_h tRed)*\varepsilon_y tRed+E_h tRed*\sqrt{(\gamma Red)^2}, & \varepsilon_y tRed<\sqrt{(\gamma Red)^2}\end{cases}\right)-\\&\left(2*\varepsilon xRed-\sqrt{(\gamma Red)^2}\right)*\\&\left(\begin{cases}-\sqrt{(\gamma Red)^2}, & -\varepsilon_y cRed<-\sqrt{(\gamma Red)^2}\\-(1-E_h cRed)*\varepsilon_y cRed-E_h cRed*\sqrt{(\gamma Red)^2}, & -\sqrt{(\gamma Red)^2}<-\varepsilon_y cRed\end{cases}\right)=0,\end{aligned} \tag{5}$$

see the designations in table 3, $\varepsilon_y tRed$ and $\varepsilon_y cRed$ – in their absolute values.

Table 4. Reduced stresses under shear and their components

Name, Functions and expressions
The largest (maximal) reduced stresses, in accordance with the plasticity conditions of Tresca - Saint-Venan*:*   Under tension $\sigma_{max}tRed = +1 * \begin{cases} \gamma_{max}Red, & 0 \le \gamma_{max}Red \le \varepsilon_y tRed \\ (1 - E_h tRed) * \varepsilon_y tRed + E_h tRed * \gamma_{max}Red, & \varepsilon_y tRed < \gamma_{max}Red \end{cases}.$ (4.1)   Under compression $\sigma_{max}cRed = -1 * \begin{cases} (1 - E_h cRed) * \varepsilon_y cRed + E_h cRed * (-\gamma_{max}Red), & -\gamma_{max}Red < \varepsilon_y cRed \\ \gamma_{max}Red, & \varepsilon_y cRed \le -\gamma_{max}Red \le 0 \end{cases}.$ (4.2)   *Main reduced stresses:*   in the direction of the main axis 1 $\sigma 1Red = \sigma_{max}tRed * \cos(\varphi 1)$, (4.3)   in the direction of the main axis 2 $\sigma 2Red = \sigma_{max}cRed * \cos(\varphi 2)$. (4.4)   *Tangential reduced stresses:*   Caused by main under tension $\tau 1Red = \frac{1}{2} * \sin(2\theta)_x * \sigma 1Red$, (4.5)   Caused by main under compression $2Red = \frac{-1}{2} * \sin(2\theta)_x * \sigma 2Red$. (4.6)   General, caused by main under tension and compression $\tau Red = \tau 1Red + \tau 2Red$. (4.7)   *Reduced normal stresses along «x» axis:*   Caused by main under tension $\sigma x1Red = \frac{1}{2} * (1 + \cos(2\theta)_x) * \sigma 1Red$. (4.8)   Caused by main under compression $\sigma x2Red = \frac{1}{2} * (1 - \cos(2\theta)_x) * \sigma 2Red$.(4.9)   General, caused by main under tension and compression $\sigma xRed = \sigma x1Red + \sigma x2Red$. (4.10)   *Reduced normal stresses along «y» axis, deducted from «symmetry»:*   Caused by main under tension $\sigma y1Red = \sigma x1Red$. (4.11)   Caused by main under compression $\sigma y2Red = \sigma x2Red$. (4.12)   General, caused by main under tension and compression $\sigma yRed = \sigma y1Red + \sigma y2Red = \sigma xRed$. (4.13)

Taking into account the symmetry of deformations (that is $\varepsilon yRed = \varepsilon xRed$) and denoting normal deformations under pure shear as « $\varepsilon xRed$ » the function of reduced deformations normal towards shear planes depending on reduced shear strins will have the following form:

$$\varepsilon_\gamma Red = f(\gamma R) = \begin{cases} f(\gamma R)_1\,, & S(\gamma) * \gamma R \le \varepsilon_y tR \text{ and } S(\gamma) * \gamma R \le \varepsilon_y cR \\ f(\gamma R)_{2\_1}\,, & \varepsilon_y cR < S(\gamma) * \gamma R \text{ and } S(\gamma) * \gamma R < \varepsilon_y tR \\ f(\gamma R)_{2\_2}\,, & \varepsilon_y tR < S(\gamma) * \gamma R \text{ and } S(\gamma) * \gamma R < \varepsilon_y cR \\ f(\gamma R)_3\,, & \varepsilon_y tR < S(\gamma) * \gamma R \text{ and } \varepsilon_y cR < S(\gamma) * \gamma R \end{cases} \quad (6)$$

where: $f(\gamma R)_1 = 0$;

$$f(\gamma R)_{2\_1} = \frac{1}{2} * \frac{(1-E_h cR) * (S(\gamma) * \varepsilon_y cR - \gamma R) * \gamma R}{(1-E_{hc}R) * \varepsilon_y cR + (1+E_h cR) * S(\gamma) * \gamma R}$$

$$f(\gamma R)_{2\_2} = \frac{-1}{2} * \frac{(1-E_h tR) * (S(\gamma) * \varepsilon_y tR - \gamma R) * \gamma R}{(1-E_h tR) * \varepsilon_y tR + (1 + E_h tR) * S(\gamma) * \gamma R}$$

$$f(\gamma R)_3 = \frac{1}{2} * \frac{\{S(\gamma)*[(1-E_hcR)*\varepsilon_y cR-(1-E_htR)*\varepsilon_y tR]+(E_hcR-E_htR)*\gamma R\}*S(\gamma)*\gamma R}{[(1-E_hcR)*\varepsilon_y cR-(1-E_htR)*\varepsilon_y tR]+(E_hcR-E_htR)*S(\gamma)*\gamma R};$$

$$f(\gamma R)_{2_2} = \frac{-1}{2} * \frac{(1-E_htR)*\left(S(\gamma)*\varepsilon_y tR-\gamma R\right)*\gamma R}{(1-E_htR)*\varepsilon_y tR+(1+E_htR)*S(\gamma)*\gamma R};$$

$$f(\gamma R)_3 = \frac{1}{2} * \frac{\left\{S(\gamma)*\left[(1-E_hcR)*\varepsilon_y cR-(1-E_htR)*\varepsilon_y tR\right]+(E_hcR-E_htR)*\gamma R\right\}*S(\gamma)*\gamma R}{\left[(1-E_hcR)*\varepsilon_y cR-(1-E_htR)*\varepsilon_y tR\right]+(E_hcR-E_htR)*S(\gamma)*\gamma R}$$

in designations «*R*» stand for «*Red*»;

see the designations in table 3;

E_hR, $\varepsilon_y tR$ and $\varepsilon_y cR$ – in their absolute values;

$S(\gamma)$ – symmetry function, in this case the sign depends from shear direction, $S(\gamma) = \begin{cases} +1, & 0 < \gamma R \\ -1, & \gamma R < 0 \end{cases}$

If we take into account that the relative volume change under pure shear equals zero (that is $\frac{\Delta V}{V} = \varepsilon x + \varepsilon y + \varepsilon z = 0$)), then reduced deformations normal to shear-free planes «$\varepsilon N_\gamma Red$ » will equal:

$$\varepsilon N_\gamma Red = \varepsilon zRed = -(\varepsilon xRed + \varepsilon yRed) = -2*\varepsilon_\gamma Red = -2*f(\gamma R), \quad (7)$$

Charts of normal reduced deformations in general form are presented on fig. 2.

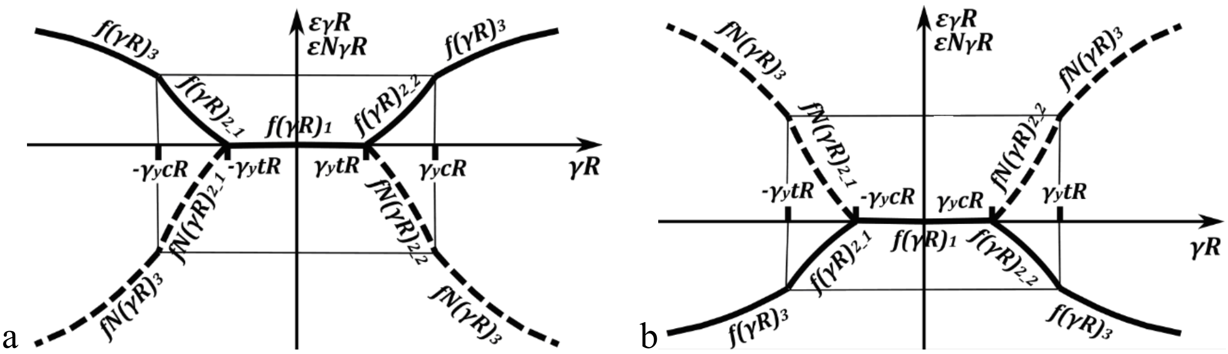


Fig. 2. Charts of normal reduced deformations depending on reduced shear:
a – when $\varepsilon_y tRed < \varepsilon_y cRed$ **; b – when** $\varepsilon_y cRed < \varepsilon_y tRed$

Function numbers on charts correspond to numbers of subfunctions by – (6). In this way, the dependences of normal reduced deformations are established under pure shear from the reduced shear strins described by the functions (6) and (7). When materials characteristics are known the relative deformations are determined according to method of their reduction (see tables 1 and 2). If in expressions (3.1) and (3.2) we replace « $\varepsilon xRed$ » and « $\varepsilon yRed$ » with «$\varepsilon_\gamma Red$ », and perform calculations of deformations in accordance with Table 3 and stresses according to table 4, we will get reduced tangential stresses depending on reduced shear strins:

$$\tau Red = \tau 1Red + \tau 2Red \ = f\tau(\gamma R) = \frac{1}{4} * \frac{1}{\gamma R} * \Bigg[\big(2 * \varepsilon_\gamma R - S(\gamma) * \gamma R\big) * \left(\begin{cases} -S(\gamma) * \gamma R, & -\varepsilon_y cR \le -S(\gamma) * \gamma R \\ -(1 - E_h cR) * \varepsilon_y cR - E_h cR * S(\gamma) * \gamma R, & -S(\gamma) * \gamma R < -S(\gamma) * \gamma R \end{cases} \right) + \big(2 * \varepsilon_\gamma R + S(\gamma) * \gamma R\big) * \left(\begin{cases} S(\gamma) * \gamma R, & S(\gamma) * \gamma R \le \varepsilon_y tR \\ (1 - E_h tR) * \varepsilon_y tR + E_h tR * S(\gamma) * \gamma R, & \varepsilon_y tR < S(\gamma) * \gamma R \end{cases} \right) \Bigg], \quad (8)$$

in designations «*R*» stands for «*Red*»; see funciton (6) for designation, tables 3 and 4; $E_h tR$, $E_h cR$, $\varepsilon_y tR$ and $\varepsilon_y cR$ – in their absolute values;

$S(\gamma)$ – symmetry function, in this case the sign depends from shear direction, зсуву,
$$S(\gamma) = \begin{cases} +1, & 0 < \gamma R \\ -1, & \gamma R < 0 \end{cases}.$$

As an example, in fig. 3 graphs of functions of reduced deformations and reduced stresses are presented.

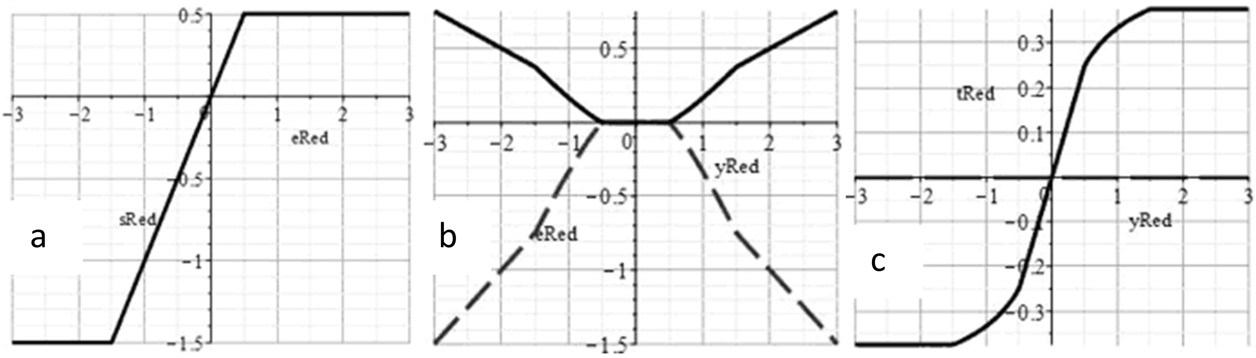


Fig. 3. Graphs of functions of reduced deformations and reduced stresses:
a – reduced diagram of materials mechanical state (stresses in tension and compression);
b – graphs of functions of normal deformations depending on shear strins (— along the «x,y»; --- along the «z»); c – graphs of tangential stresses depending on shear strins (— tangential; --- normal)

The ratio of the elasticity limit under compression to the elasticity limit under tension equals three. Hardening caused by plastic deformations is absent (hardening characteristic equals zero).

Conclusions. In studies of a flat stressed-strain state of a continuous medium under conditions of pure shear, the funcitons of normal deformation are deducded depending on shear-strins. The function of deformations normal to the shear planes (5) and the function of deformations normal to planes free of displacement (6). Functions terms of use: a diagram of the mechanical state of single-axle compression-stretching is trilinear with strengthening or without strengthening; reduced characteristic of the strengthening is equal to zero or more than zero, but not more than one; solving problems on the condition of plasticity of Tresca - Saint-Venan.

When testing elements of structures (samples) made of materials with different plastic properties when tensile and compression, it is recommended to take into account the presence of normal deformations when shearing.

REFERENCES

1. Bolshakov V. Integration of sustainability principles in curriculum of civil engineering and architecture specialization/ Bolshakov V., Savytskyi M., Babenko M.// Economics bulletin NMU — 2016 — 14 – pp. 14-19.
2. Belyaev N. M. Soprotivlenie materialov. - Moskva: Nauka, 1978. - 608 p. (in Russian).
3. Kovalchuk B. I., Lebedev A. A., Umanskiy S. E. Mehanika neuprugogo deformirovaniya materialov i elementov konstruktsiy. - Kiev: Naukova dumka, 1987. - 280 p. (in Russian).
4. Pisarenko G. S., Lebedev A. A. Deformirovanie i prochnost materialov pri slozhnom napryazhennom sostoyanii. - Kiev: Naukova dumka, 1976. - 608 p. (in Russian).
5. Primakov V.P. Matematicheskoy modeli opisaniya diagramm rastyazheniya (szhatiya) konstruktsionnyih materialov/ Primakov V.P., Pogrebnyak N.A., Ovsienko E. I., Naumenko E. I. // «Stroitelnoe proizvodstvo». Mezhvedomstvennyiy nauchno-tehnicheskiy sbornik. – 2007. - Vyip. 48. – Kiev: NIISP – 2007. – pp. 40-44. (in Russian).
6. Rabotnov Yu.N. Soprotivlenie materialov. - Moskva: Fizmatgiz, 1962. - 456 p. (in Russian).
7. Timoshenko S. P., Dzh. Gere. Mehanika materialov. - Moskva: Mir, 1976. - 667 p. (in Russian).
8. Yatsenko V.F. Prochnost kompozitsionnyih materialov. - Kiev: Vyischa shkola, 1988. - 197 p. (in Russian).

CHAPTER III

RENEWABLE ENERGY. HEATING, VENTILATING, AND AIR-CONDITIONING

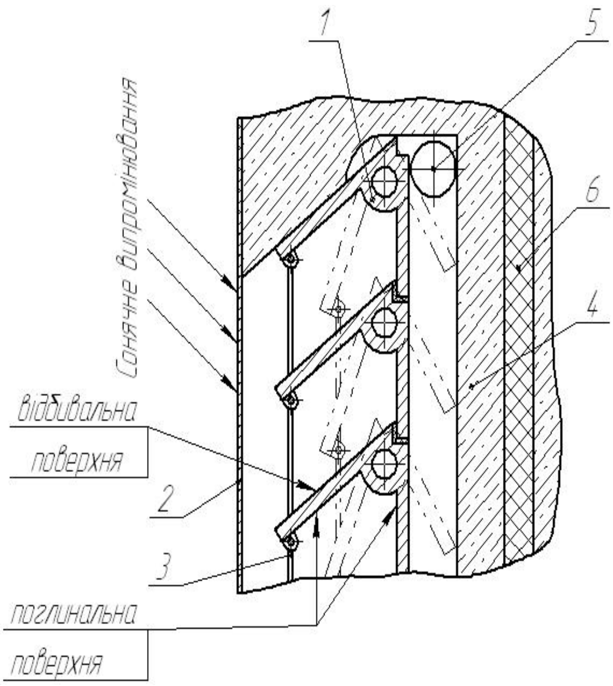
3.1. IMPROVEMENT OF RELIABILITY OF CONVERTERS OF RENEWABLE ENERGY CONSIDERING THE CHARACTERISTICS OF PROBLEM AREAS

Nakashydze Liliya, Nakashydze Irina, Brynin Yevhen

While using solar radiation, heat of the environment etc. in systems of air conditioning, it is reasonable to take into account that simple mechanical connection of renewable energy converters to the objects of traditional architecture can lead to an increase in the load on the design and not always a successful change in the thermal engineering parameters of the base enclosing structures and the architecture of the constructions.

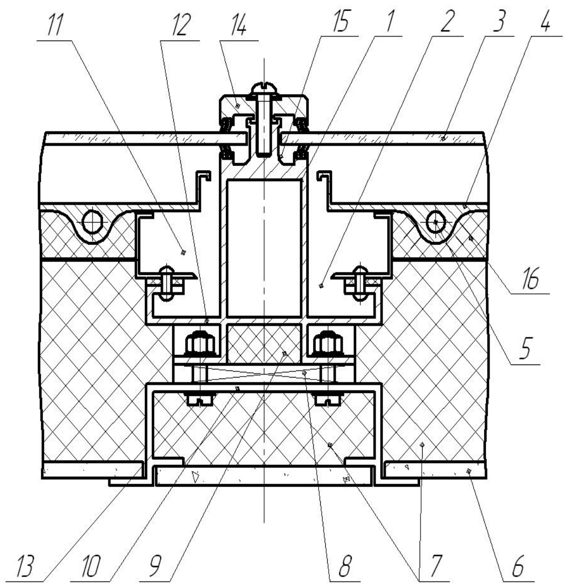
It is possible to eliminate these disadvantages by using air-conditioning converters in climate systems; in particular, such innovative design as energy-active fences. Such converters of renewable energy sources (RES) [1-4] allow to receive, transform, redistribute and accumulate energy in a controlled manner. Their use provides a positive energy balance between the energy from solar radiation and the environment and its losses.

Such constructive elements of the climate system as the RES converters like energy-active fences combine both passive and active elements of the structure. In addition to preventing the microclimate from environmental degradation, in the design of energy-active fences, the functional direct-regulated conversion of energy from the environment and solar radiation to thermal and/or electrical energy, transportation, accumulation, supply/discharge and radiation of thermal energy is established. These functions are realized by introducing in the design of the RES converter the energy-sensitive layers and elements, the channels of transport of the coolant, energy accumulation zones. Examples of such constructs [3] are presented in Fig. 1, 2.



1 – heat exchanger tubes, 2 – translucent coating, 3 – traction, 4 – wall of construction, 5 – ventilation duct, 6 – thermal insulation

Fig. 1 – Converter of RES (energy-active fence), which prevents overheating of the building



1, 10 – rafters, 2, 11 – compartments, 3 – glass, 4 – heat absorbing element, 5 – channel with heat carrier, 6 – sheathing, 7 – thermal insulation, 8, 9 – insulating gaskets, 12 – outlet tray, 13 – bolts, 14 – fasteners, 15 – gutters

Fig. 2 – A version of the RES converter with closed sections

The multilayer construction of RES converters in heat engineering is heterogeneous. They represent multi-layered complex systems made of various materials. The peculiarity of the technological use of the converters of RES is the presence of a large number of fastening elements, inter-panel joints, corner joints etc. on the base structures of construction (walls, roofs). Therefore, it is important to have information about the features of the heat engineering characteristics of the problem areas.

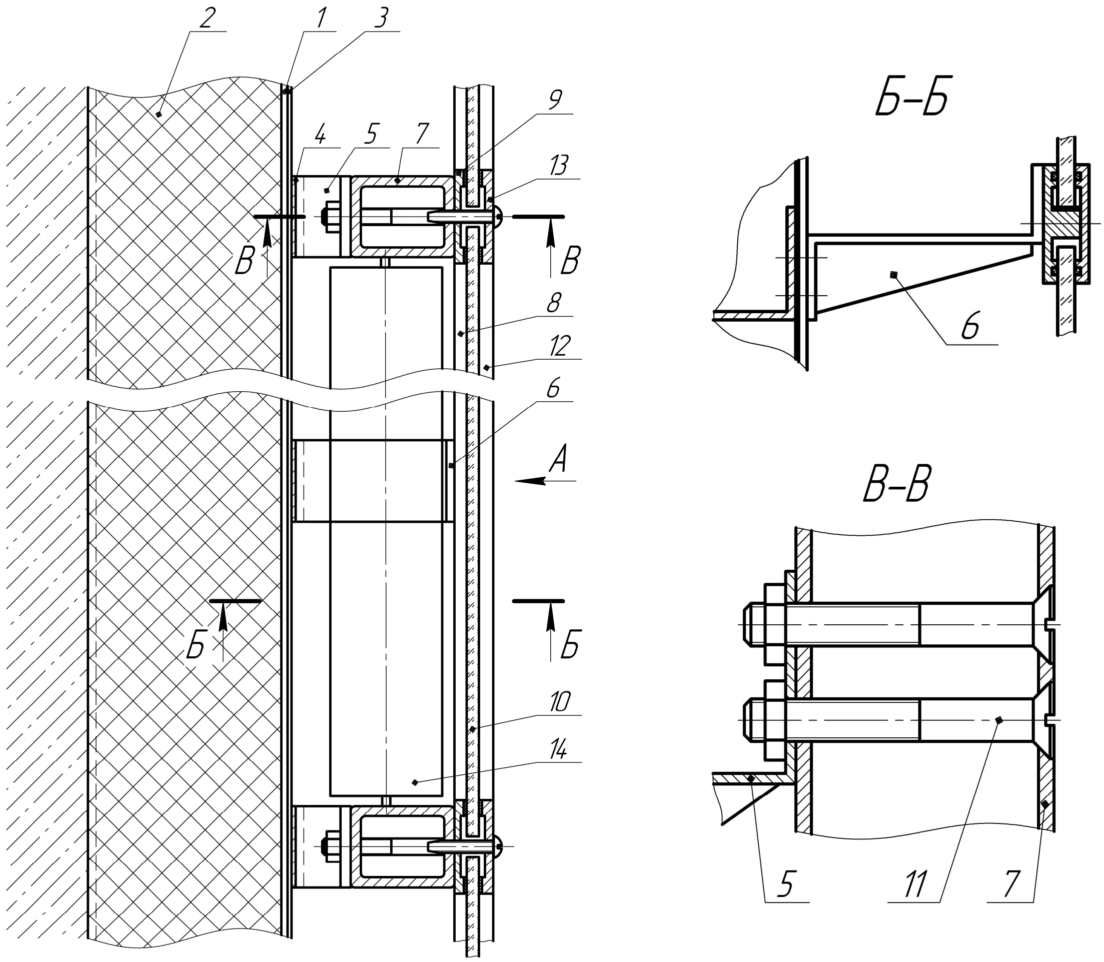
Estimation of the peculiarities of the thermophysical properties of such structures and their interfaces with the basic constructions can be carried out according to several standard methods.

In accordance with the methodology presented in [5], it is valuable to determine the heat-engineering properties of converters of RES:

- determination of the mean value of the resistance of heat transfer (this index must exceed the resistance required by the normative documents);

- determination of the required heat-protective properties of the least protected areas (this is necessary to ensure temperatures above dew point and to exclude condensation conditions).

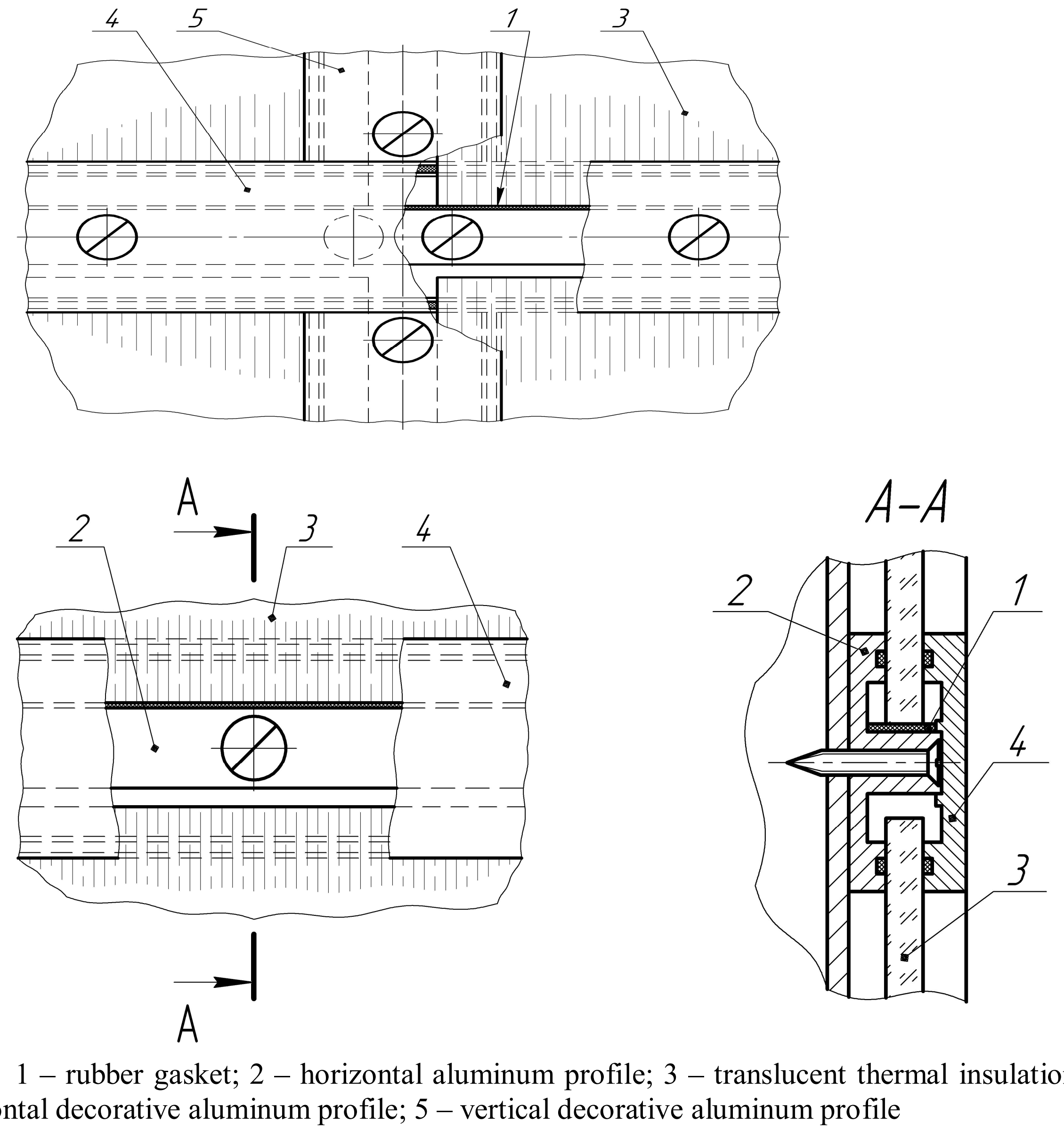
But such methods are rather complicated in the calculation, since it is necessary to take into account a large data array related to various physical and technical factors that affect the characteristics of the elements of the design of the converter and the basic elements of the structure.



1 – Z-profile; 2 – mineral wool insulation; 3 – wind barrier; 4 – clamping strap; 5 – bracket; 6 – auxiliary bracket; 7 – stand; 8 – horizontal aluminum profile; 9 – vertical aluminum profile; 10 – translucent thermal insulation; 11 – screw with a nut; 12 – horizontal decorative aluminum profile; 13 – vertical decorative aluminum profile; 14 – blocks of blinds; 15 – window

Fig. 3 – An example of the location of the converter of RES on the basic construction structures and mounting elements

Therefore, in prediction of thermal engineering features of structures that use the power supply system with converters of RES, which are integrated in the basic constructions, it is necessary to take into account thermal inhomogeneity. The change in thermotechnical properties is determined by the presence of structural elements made of metal or other materials, i.e. determines the appearance of bridges of cold in such areas. Losses that accompany excessive conjugates, joints make up 47% of the total thermal loss of structures. These factors influence the temperature and humidity fields during the operation of the structures.



1 – rubber gasket; 2 – horizontal aluminum profile; 3 – translucent thermal insulation; 4 – horizontal decorative aluminum profile; 5 – vertical decorative aluminum profile

Fig. 4 - Mounting elements for translucent insulation

In order to determine the thermophysical parameters of the conjugation basic structure – converter of RES it is proposed to use an objective parameter – the reduced resistance to heat transfer. This indicator allows estimating the influence of technological conjugates when placing the reactors on the base structures of RES. In accordance with [6-8], the reduced resistance of heat transfer is understood as a value equal to the ratio of the air temperature difference washing the multi-layered enclosing structure to its average area of specific heat flux in the stationary thermal regime. For a geometrically complex fence, the reduced resistance to heat transfer is a value equal to the resistance to the heat transfer of a uniform fence, the heat flux through which is equal to the heat flux through the complex conjugation under consideration.

The reduced resistance to heat transfer makes it possible to increase the reliability of determining the loss of heat through the i-th layer of the multi-layered interface the basic fence–converter of RES. In accordance with [6, 7], heat losses through the i-th layer of constructive conjugation are determined in accordance with the mathematical dependence:

$$Q = \frac{\iota}{R_T^{np}} t_B - t_H \cdot n \cdot l + \beta_i \qquad (1)$$

where: Q – loss of heat through the i-th layer of the interface basic guard-converter of RES, W;

F_i – surface area of the structural interface, m^2;

R_T^{np} – reduced resistance of the heat transfer of the interface basic fencing-converter of RES, m^2 s / W;

t_B, $t_н$ – design temperatures inside the room and outside air, ^{0}C;

β – coefficient, that takes into account the level of heat loss through the interface the basic fence – converter of RES.

The advantage of using such indicator as the value of the reduced resistance of heat transfer is that it takes into account the peculiarities of the formation of the thermal coupling regime of the basic fence–converter of RES, i.e. takes into account the features of the angular sections, protruding sections, heat-conducting inclusions etc.

This approach allows promptly calculating of structures' thermal characteristics, the basic designs of which integrate RES converters. The calculated data will be decisive in determining the level of buildings' energy savings.

In accordance with the proposed methodology, the determination of the change in the values of the heat transfer coefficient or resistance to heat transfer for coupling, the basic fence–converter of RES is performed individually for each thermal inclusion (technological fastenings, joints, etc.) in accordance with the methodology presented in [8, 9], possibly by a simplified scheme or by calculating 2 or 3-dimensional temperature fields. It is assumed that the influence of the difference in the temperature field of each inclusion on the temperature field of the conjugate elements is not taken into account in the baseline fence–converter of RES. At the same time, the account of the influence of heat-conducting inclusions and thermal-engineering inhomogeneities is based on the European standard [10].

The above resistance of the heat transfer of the interface section, the basic fence–converter of RES can be calculated in accordance with the expression:

$$K + \sum l_j \psi_j + \sum \eta_k \chi_k \qquad K + \sum \Lambda K \tag{2}$$

where: K – coefficient of heat transfer in the design hood, W / m^2 s.

At the same time, the heat transfer coefficient is calculated by the formula:

$$\overline{\alpha_B} + \sum_S \left(\overline{\lambda}\right)_S + \overline{\alpha_H} \tag{3}$$

where: R_T^{np} – conditional resistance to heat transfer over the interface surface basic fence–converter of RES, m^2 s / W;

Ψ_j – specific heat losses through linear heterogeneity of the j-th type of coupling basic fence–converter of RES, W / m^2 s;

l_j – length of linear heterogeneity of the fragment of the j-th type, per 1m^2 of the fragment of interface the basic construction–converter of RES, m / m^2;

X_k – specific losses of heat of interface basic construction–converter of RES through point inhomogeneity of the k-th type, W / ^{0}C;

N_k – the number of point inhomogeneities of the k-th type, which is clinging to 1m^2 of the interface fragment the basic construction–converter of RES, pcs / m^2.

In accordance with the presented methodology, it is possible to simplify the assessment of the effect of heat transfer of various interfaces in the basic construction–RES converter.

Mentioned heat transmission resistance, which is proposed to use as a criterion for evaluating the thermal characteristics of the conjugate base fence–converter of RES, enables to set the level of the thermal protection in these areas objectively and quickly.

The use of the proposed methodology allows consideration of the features of operation of certain problem areas of constructive interfaces, including those that are technologically equipped with the largest number of thermal conductive inclusions per unit area, i.e. to determine the worst heat-shielding characteristics by which heat losses of building premises should be determined.

REFERENCES

1. Nakashydze L.V., Gabrinets V.A. Osnovnyie elementy innovatsionnoy kompleksnoy sistemy klimatizatsii s ispolzovaniem energii alternativnyih istochnikov [The main elements of an innovative integrated air-conditioning system, using alternative energy sources]. Stroitelstvo, materialovedenie, mashinostroenie. Seriya: Sozdanie vyisokotehnologicheskih ekokompleksov v Ukraine na osnove kontseptsii sbalansirovannogo (ustoychivogo) razvitiya [Construction, materials science, machine building. Series: Creation of high-tech eco-complexes in Ukraine on the basis of the concept of balanced (sustainable) development]. Dnipropetrovsk, 2013. Vol 68, pp. 240-243. (in Russian).

2. Zaiavka na korysnu model № u 201601390, Ukraina, MPK F24G 2/50 , E04B 1/76 Enerhoaktyvne ohorodzhennia [Energy-active fence] / L.V. Nakashydze, M.V. Shevchenko, V.O. Habrynets (Ukraina), zaiavl. 16.02.2016. (in Ukrainian).
3. Gabrinets V.O., Nakashydze L.V., Sokol G.I. and others Formuvannia skhemnykh rishen systemy aklimatyzatsii sporud v robochomu seredovyshchi alternatyvnykh dzherel enerhii [Formation of schematic solutions of the system of acclimatization of buildings in the working environment of alternative energy sources]: monohrafiia. Dnipro, 2016, 150 p. (in Ukrainian)
4. Nakashydze L.V. Uluchshenie ekspluatatsionnyih harakteristik sooruzheniy pri ispolzovanii energii alternativnyih istochnikov [Improving the operational characteristics of buildings using alternative energy sources]. Mezhdunarodnyiy nauchnyiy zhurnal «Alternativnaya energetika i ekologiya» [International Scientific Journal "Alternative Energy and Ecology"]. 2014, no.23, pp. 84-89. (in Russian).
5. Ilinskiy V.M. Stroitelnaya teplofizika (ograzhdayuschie konstruktsii i mikroklimat zdaniy) [Building Thermophysics (building envelopes and microclimate of buildings)]. Moskva, , 1974, 320 p. (in Russian).
6. Protasevich A.M. Stroitelnaya teplofizika ograzhdayuschih konstruktsiy i mikroklimat pomescheniy [Building thermophysics of enclosing structures and microclimate of premises]. Minsk, 2016, 452 p. (in Russian).
7. Gagarin V.G., Kozlov V.V. Teoreticheskie predposyilki rascheta privdennogo soprotivleniya teploperedache ograzhdayuschih konstruktsiy [Theoretical prerequisites for calculating the resistance transferred to the heat transfer of enclosing structures]. Stroitelnyie materialy [Building Materials].2010, no.12, pp. 4-12. (in Russian).
8. Fokin V. M., Boykov G. P., Vidin Yu. V. Osnovyi energosberezheniya v voprosah teploobmena [Basis of energy saving in heat exchange issues] Moskva, 2005, 192 p. (in Russian).
9. Kornienko S.V. Povyishenie effektivnosti zdaniy za schet snizheniya teplopoter cherez krevyie zonyi ograzhdayuschih konstruktsiy [Increasing the efficiency of buildings by reducing heat loss through the cracked areas of enclosing structures]. Zhurnal RAAN. ASA DEMIA, Stroitelstvo i arhitektura [Journal RAAN. ACADEMIA, Construction and architecture]. 2010, no.3, pp. 348-351. (in Russian).
10. DIN EN ISO 10211-2:2001 Wärmeströme und Oberflächentemperaturen. Teil2 Linienförmige Wärmebrücken. Juni 2001. Available at: https://www.scribd.com/document /255729877/Din-En-Iso-10211-2. (in German).

3.2. EXPERIMENTAL RESULTS OF COILED JETS INTERACTING AT A CONVERGENT ANGLE IN HEAT-GENERATING INSTALLATIONS

Zaytsev Oleg, Borysenko Kristina, Zaitsev Mykyta

The current state of fuel and energy resources, the rise in the cost of their extraction, requires the effective use of the energy received. However, the heat and power equipment is installed from the calculation of maximum loads, with a small margin of variation in the generation of thermal energy, which does not ensure the efficient use of fuel.

Achieving the optimum heat dissipation in low-power heat generators (up to 300 kW) with the help of existing regulation methods [1-3] is currently difficult from an economic point of view [4-7]. At the same time, the widespread use of rotating flows, the scope of which covers the processes of production of heat energy, transmission and use of it, as well as processes associated with the use of heat in technological processes (in particular, welding technologies, reaching 70% in the assembly of heat and power equipment) . In this case, the use of aerodynamics of rotating flows (centrifugal effect, the emergence of reverse currents in the central region) allows solving the problems of intensifying production processes, optimizing the operation of the equipment and its design parameters [1, 5-7, 10].

However, the instability of the processes occurring during the primary decay of the swirling flow (appearance of the region of the recurrent flow), the appearance and degeneration of the vortex precessing nucleus for certain values of the degree of flow twist, as well as the insufficient study of the processes that occur during the interaction of rotating flows and the lack of reliable methods of stabilizing and controlling them, causes considerable difficulties when applying twist in technological processes [1, 8-10], which requires an analysis of the reasons for the low efficiency of the application of rotating flows in thermal processes.

Experimental studies of this process were carried out on an experimental bench [8-10], whose photograph is shown in Fig. 1, with the flow velocities measured by a thermoelectric anemometer at each point in 10 s, 30 s, 60 s, 90 s, 120 s. The center of the coordinate grid was located in the middle between the axes of the branch pipes. The measurements were carried out in the vertical and horizontal axes in steps of 0.05 m in each section (0.1, 0.15, 0.2, 0.25, 0.3 m from the branch pipe). The distance between the nozzles at the angular position of the nozzles (15˚, 30˚, 45˚, 60˚) of the distance to the cross-section was determined from the center of the axis at the cutoff of the nozzles. With the corresponding designation in Figures 2-5:

♦ - at a distance Z = -0.3 m from the axis of the jet; ■ - at a distance Z = -0.25 m from the axis of the jet; ▲ - at a distance Z = -0.2 m from the axis of the jet; x - at a distance Z = -0.15 m from the axis of the jet; x - at a distance Z = -0.1 m from the axis of the jet; • - at a distance Z = -0.05 m from the axis of the jet; + - on the axis of the jet; ▬ - at a distance Z = 0.05 m from the axis of the jet; ▬ - at a distance Z = 0,1 m from the axis of the jet; ◊ - at a distance Z = 0.15 m from the axis of the jet; □ - at a distance Z = 0.2 m from the axis of the jet; Δ - at a distance Z = 0.25 m from the axis of the jet; x - at a distance Z = 0.3 m from the axis of the jet; x - at a distance Z = 0.35 m from the axis of the jet; ○ - at a distance Z = 0,4 m from the axis of the jet.

Thus, an analysis of the distribution of the radial component of the velocity with the merging of rotating jets at an angle of 15 ° as the mixing zone develops shows that the oscillations appear as the jets move, while the amplitude of the oscillations remains practically constant, but, in contrast to the interacting parallel rotating jets, the region interactions more. Oscillations of the tangential component of the velocity when interacting at an angle of 15 ° arise immediately at the cutoff of the branch pipes in the central region of the resulting flow, while at a distance of 3 gauges the velocity distribution is analogous to the parallel mixing of rotating jets at a distance of 2 gauges with a spacing of 0.1 m. the tangential velocity remains constant with distance from the nozzles, although at a distance of 5 gauges the velocity is greater than in the case of parallel interaction. The analysis of the oscillations of the axial velocity component, shown in Fig. 2, revealed that the largest values of the oscillations are observed in the zone of interaction of the rotating flows, but the velocity decreases more slowly than in the case of parallel interaction, and the amplitude of the oscillations remains practically constant.

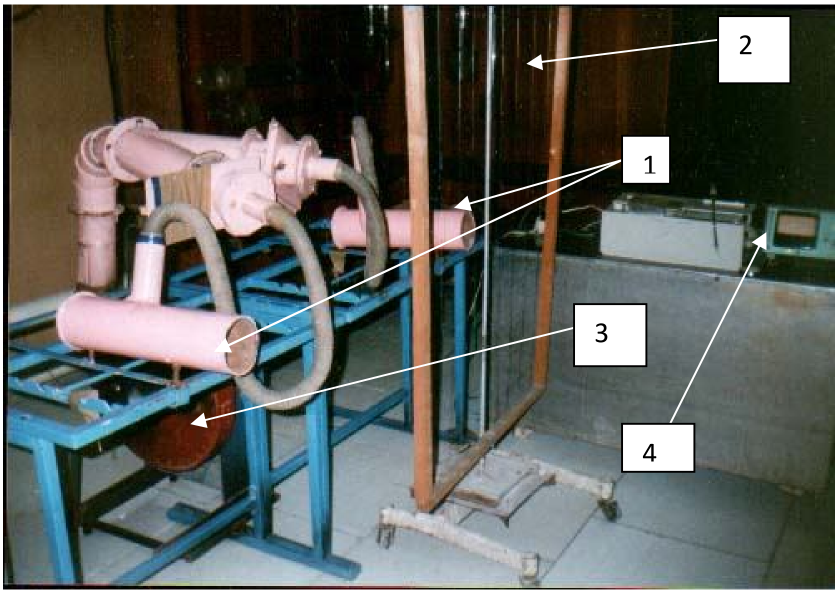


Fig.1. Photo of the experimental stand:

1- supply pipes, ø 0,1 m; 2 - grid coordinates, with a step of 0.05 m; 3 - fan №8; 4 - thermoelectric anemometer

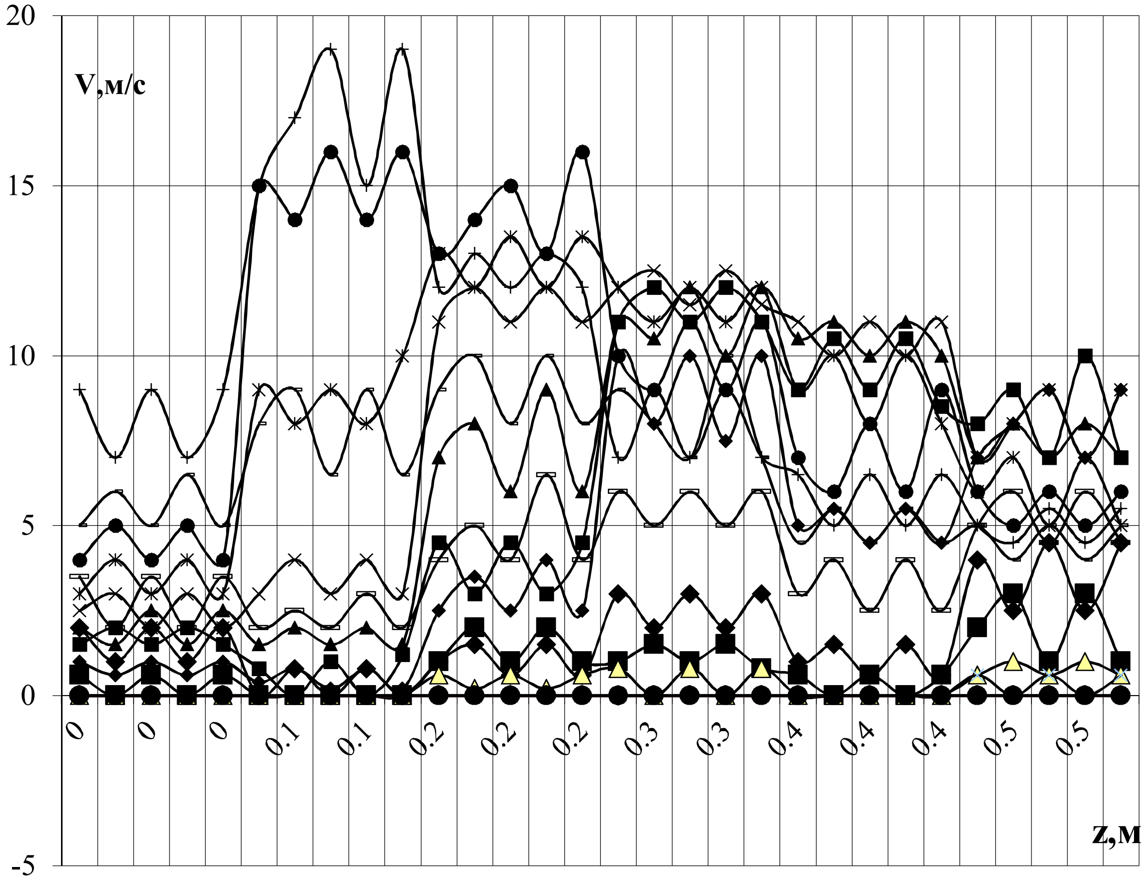


Fig.2. The generalized distribution of the axial velocity with respect to time when the twisted jets interact at an angle of 15 °

The distribution of the radial component during the interaction of rotating jets at an angle of 30 °, obtained at the intervals indicated earlier, showed similarity to their velocity fields with parallel interaction of rotating jets (the distance between the axes is 1 diameter), although the amplitude of the oscillations is less in this case.

The oscillations of the tangential component of the velocity have a distribution similar to the merging of parallel rotating currents, but even at a distance between the axes of 2 diameters, which is explained by the large angle of attack of the jets.

In the distribution of the generalized axial velocity component with respect to time and jet length, as shown in Fig. 3, there is also an analogy with interacting parallel jets in which the distance between the axes is equal to 2 diameters, although the amplitude of the oscillations in this case is much smaller.

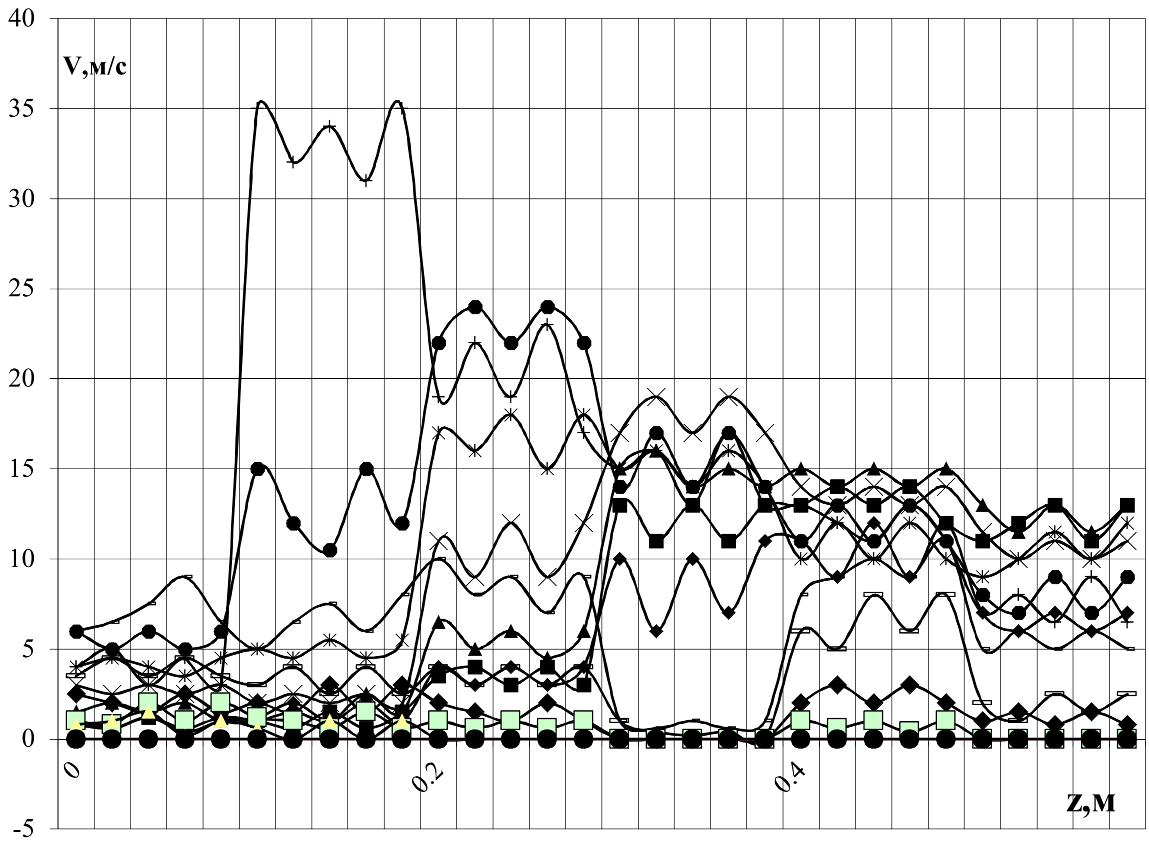


Fig.3. The generalized distribution of the axial velocity with respect to time when the twisted jets interact at an angle of 30 °

The radial velocity oscillations when mixing rotating jets at an angle of 45 ° have the greatest amplitude in the central part of the resulting flow, which corresponds to the interaction zone of the flows. The changes in the tangential velocity component with time have a smaller amplitude.

Analysis of the generalized picture of the oscillations of the axial velocities shown in Fig. 4 allows us to state that the oscillations are of an opposite nature with respect to the horizontal axis, while their amplitude increases in the zone of active jet mixing (axial velocities have the same direction as the jet movement) and decreases when interacting internal layers of jets.

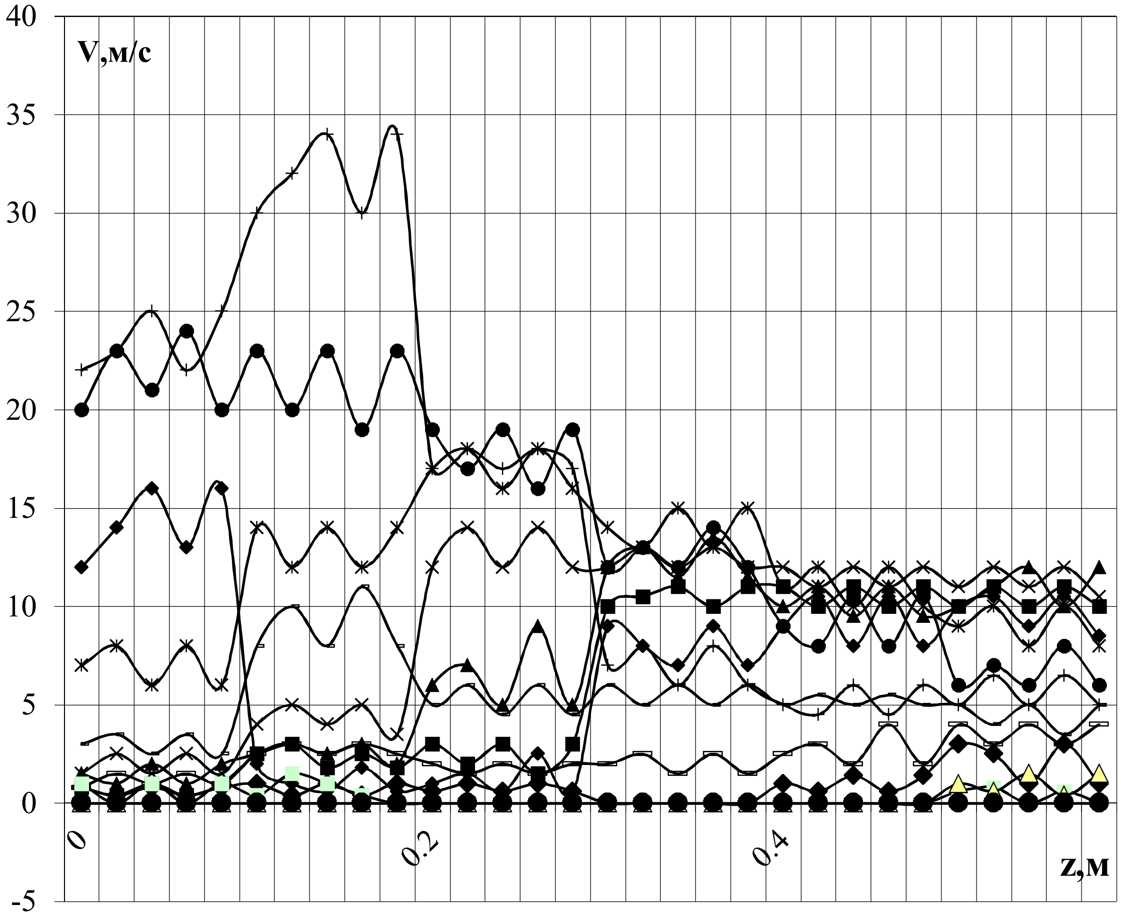


Fig.4. The generalized distribution of the axial velocity with respect to time when the twisted jets interact at an angle of 45 °

In the interaction of rotating jets at an angle of 60 °, the radial and tangential velocity variations have an almost constant amplitude, while their directions are opposite with respect to the horizontal axis, and the axial velocity oscillations differ from the cases considered earlier by the propagation of inverse currents on the zone, and this zone is formed not by the structure a separate swirling jet, and the influx of air from the environment to the mixing zone flows.

The analysis of the time variation of all the velocity components at the angles of interaction of rotating jets, shown in Fig. 5, revealed that their periodicity is 60 s. It is also necessary to note the opposite direction of the oscillation phases for the layers of the resulting flow, which are symmetric with respect to the horizontal axis.

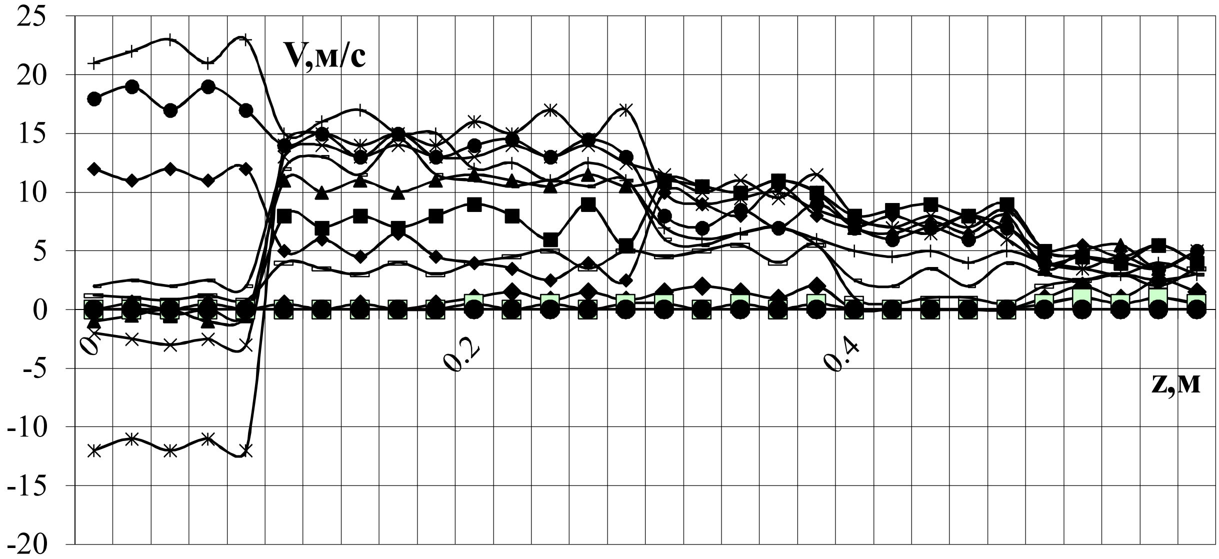


Fig.5. The generalized distribution of the axial velocity with respect to time when the twisted jets interact at an angle of 60 °

Thus, an analysis of the experimental data on the oscillations of the resultant velocity when mixing rotating jets at different angles made it possible to draw the following conclusions:

- the distribution of the radial component of the velocity during the confluence of the rotating jets depends on the development of the mixing zone, that is, the oscillations appear as the resulting flow forms, while the amplitude of the oscillations remains practically constant, but, in contrast to the interacting parallel rotating jets, the interaction region is larger;

- oscillations of the tangential component of the velocity are observed in any part of the development of the flow, while the tangential velocity profile remains constant as far as the distance from the nozzles, although at a distance of 5 gauges the velocity is greater than in the case of parallel interaction;

- the largest values of the oscillations of the axial velocity component are observed in the zone of interaction of the rotating flows, but the velocity decreases more slowly than in the case of parallel interaction, and the amplitude of the oscillations remains practically constant. In addition, the oscillations are of the opposite nature with respect to the horizontal axis and extend to the zone of reverse currents, whereby this zone is formed not by the structure of a single swirling jet, but by the influx of air from the environment to the mixing zone of the flows.

REFERENCES

1. Gupta A, Lilly D, Sayred N. Swirling flows. [Moscow: Mir]. 1987. 588 p.
2. Schlichting G. The theory of the boundary layer. [Trans. from German. - Moscow: Nauka], 1974. - 711 pp.
3. Averkova, O.A., Logachev, I.N., Logachev, K.I., Zaytsev, O.N. Cross-flow of air through sealed elevator enclosures //[5th International Conference on Particle-Based Methods – Fundamentals and Applications, PARTICLES] 2017. P. 33-44.
4. Shtym AN, Shtym KA, Dorogov EY. Boiler installations with cyclone pretoptacks: monograph. [Publishing House Dalnevos.federal.un-ta], 2012. 421 p.
5. Bystrov YA., Isaev SA, Kudryavtsev NA, Leontiev AI. Numerical simulation of vortex intensification of heat exchange in stacks of pipes. [St. Petersburg . Shipbuilding].2005. 392 p.
6. Dovmir NM. Low-temperature modes of heating systems as a prerequisite for the efficient use of condensing boilers and heat pumps. [Prom. Heat engineering]. 2008. №5. p. 62-68
7. Grimitlin AM, Datsyuk TA, Denisikhina DM. Mathematical modeling in the design of ventilation and air conditioning systems: monograph. [St. Petersburg. ABOK North-West].2013, 192 p.
8. Yurchenko O, Lyubarets A, Dikhtyar T, Zaitsev O. Experimental studies of velocity oscillations in a strongly-twisted gas jet with a precessing's vortex core. [Lublin. Motrol 12C]. 2012. 266-272. (in Ukrainian)
9. Zaitsev O, ToporenS, Shmonyak V, Nakonechniy V. Stability of a rotating gas stream in the change in the extent of its twist [Motrol Motoryzacja i energetyka rolnictwa. Lublin. 11B], 2009. 164-167. (in Ukrainian)
10. Yurchenko O, Lyubarets A, Dikhtyar T, Zaitsev O. Experimental studies of velocity oscillations in a strongly-twisted gas jet with a precessing vortex core. [Lublin. Motrol 12C].2010. p. 266-272. (in Ukrainian)

3.3. THE PROJECT OF "BUSINESS HOUSE" FOR THE CONSTRUCTION OF INNOVATIVE HOUSING ESTATE TYPE

Perehinets Ivan, Yurchenko Yevhenii, Koval Olena, Pipa Volodymyr

This paper presents a study of synergistic opportunities and analysis of future activities of the scientific and industrial clusters of low-rise residential housing construction in Ukraine in terms of social and economic transformation. In a period of rapid structural change of social and economic formations, it becomes necessary to move the permanent production systems on to the cluster, which, in essence, is relevant to such changes. The cluster approach in the organization of production produces a synergistic effect of enterprises, and is a logical tool for development of low-rise residential housing, as well as the basis for solving the housing problem, and an example of the development of all sectors of the Ukrainian economy [4,5,6,7]. The purpose of this scientific project is to create a business for designing, construction and operation of innovative low-rise housing estate type. Houses will be equipped with solar power plants, which will allow homeowners to get rid of utility bills, and will allow the sale of surplus electricity by the "green tariff".

Description of the scientific idea. In Ukraine, there is a stable, non-structured market for individual housing construction with a volume of 6.5 - 7.0 million m^2. That is about 60,000 units (not including undeclared individual constructions), with the total cost of USD 6-8 billion. The innovative organization and management of the construction of houses based on cluster systems can significantly reduce the cost of housing with the simultaneous improvement of quality and compliance with world standards of economy, ecology, energy efficiency, and the principles of healthy housing [9].

We have developed a product line of individual residential buildings equipped with solar power plants for the sale of electricity under the "green tariff". The houses have significant advantages and benefits for buyers in comparison with existing analogues in architectural and technical, as well as financial and economic indicators throughout the life cycle of the building.

With the help of the "BusinessHouse" business idea several vital issues of the modern Ukrainian household are being addressed:

- providing world standard housing [4];
- homeowners receiving permanent passive income from the electricity sales under the "green tariff", bound to a convertible currency – Euro (shown in Fig.2);
- homeowners receiving constant information, knowledge and skills in the issues of professional operation of energy-efficient facilities;
- homeowners receiving monthly payments for providing information and analytical services about their house during the first three years of operation.

Implementation of this idea will provide quite new opportunities for consumers - families can get their potential in:

- owning energy-efficient housing;
- income growth;
- child education and upbringing;
- recreational properties of individual housing;
- meeting the best world standards at lower prices.

The project has a significant innovative component that clearly delineates the old - rudimentary approaches to the construction of individual housing, as a set of certain construction and installation works with engineering support elements, from the modern industrial-intellectual format of the house with specified performance characteristics. The advantages of such a format are so obvious that they convince the project initiators in its success.

At the moment the following developments are available:

- A developed product line of 4 project solutions (shown in Fig.1).
- The price of houses as final commodity units is determined, it is identical throughout Ukraine.
- The organizational structure of the project based on the cluster system is defined.

- A marketing strategy for entering the market is developed.

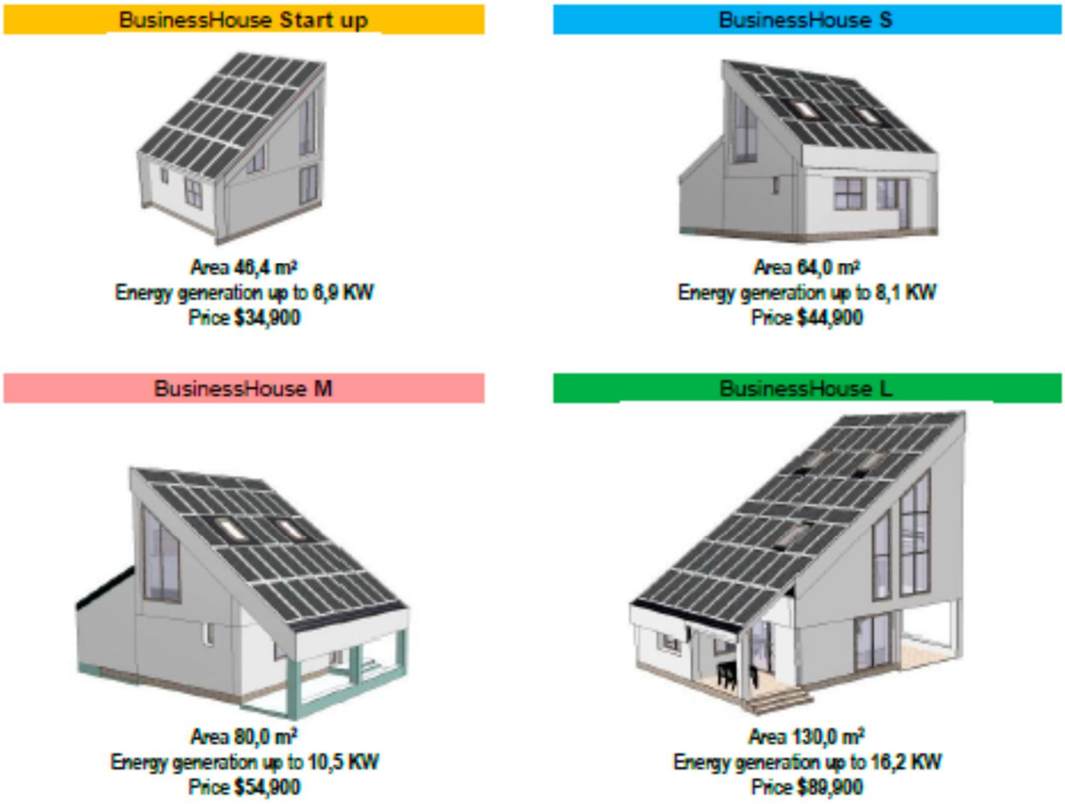


Figure 1. Typical houses in the framework of the "BusinessHouse" concept

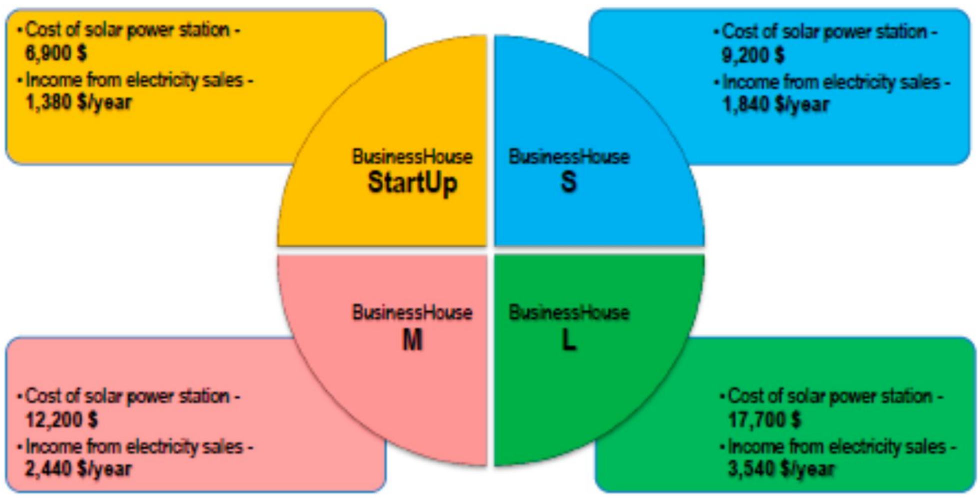


Figure 2. Revenues from the sale of surplus electricity categorized by the type of house

Territorial distribution of the "green tariff" in Ukraine is shown in Fig. 3.

Figure 3. Territorial distribution of the "green tariff" in Ukraine [3]

The example of energy output calculation of a solar power plant (SPP) is shown in Fig. 4. The example of monthly energy generation of SPP is shown in Fig.5. The results of a preliminary calculation of energy output obtained from a 7 kW solar power station are given in Tab. 1. The results of a preliminary calculation of energy output obtained from a 16 kW solar power station are given in Tab. 2.

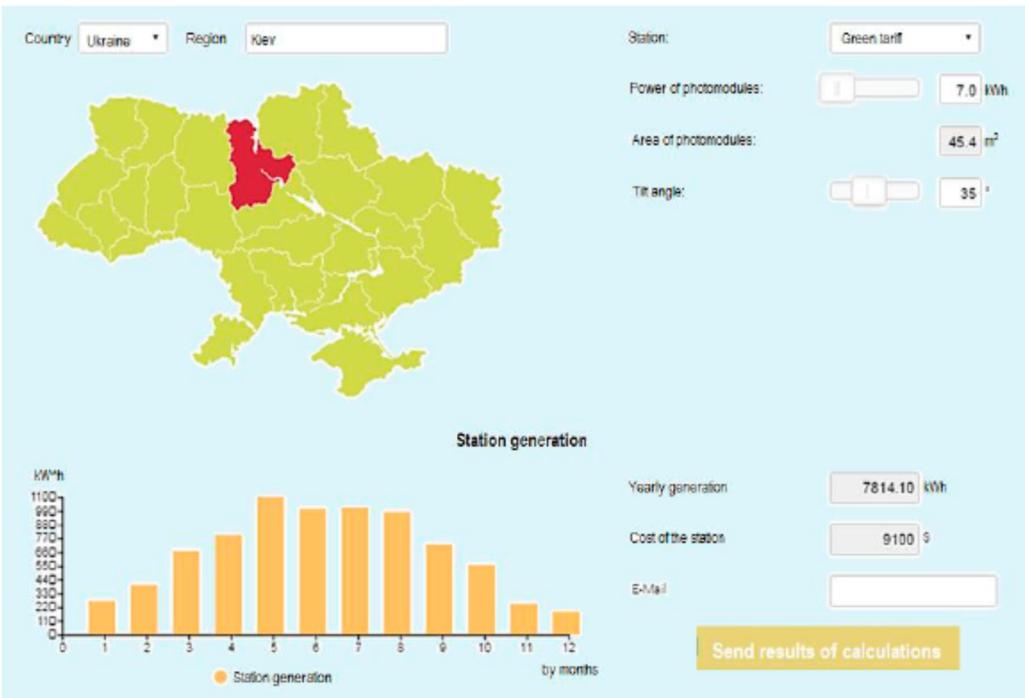


Figure 4. Example of solar power plant energy output estimate in the Kiev region

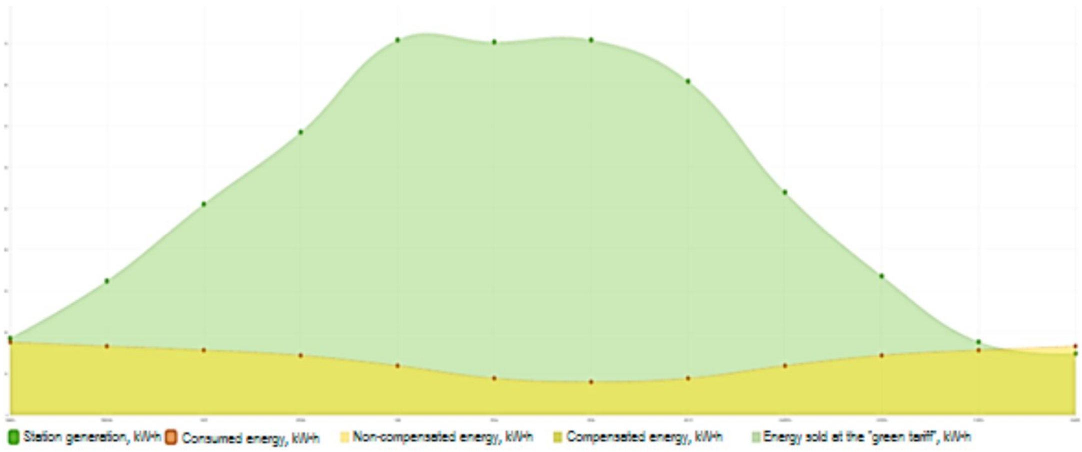


Figure 5. Example of solar power plant monthly generation

Table 1. Preliminary calculation of generated energy of a 7 kW solar power station

Parameter	Calc. unit	Value
Energy output of a solar power plant per year	kW·h	8 048
Annual consumption of the object	kW·h	2 008
Non-compensated energy station	kW·h	22
Energy sold at a "green" rate	kW·h	6 062
Electricity-compensated station	kW·h	1 986
Estimated cost of the power plant	USD	9 100
Income from the power plant operation per year	USD	1 761

Table 2. Preliminary calculation of generated energy of a 16 kW solar power station

Parameter	Calc. unit	Value
Energy output of solar power plant per year	kW·h	18 108
Annual consumption of the object	kW·h	3 000
Energy sold at a "green" rate	kW·h	15 108
Electricity-compensated station	kW·h	3 000
Estimated cost of the power plant	USD	20 800
Income from the power plant operation per year	USD	4 241

Opportunities of the "BusinessHouse" scientific idea:

- Significant market capacity including deferred demand. A stable trend in society to save energy. Growth in demand for a high-tech product.

- Relative novelty of the product.
- Wide representation of the company in all regions of the country. Display of the exhibition samples.
- Significant increase in the cost of energy. Growth in the income level of the population.
- Increase of legal and economic culture of the population. Widespread introduction of a "green tariff" concept to raise public awareness.
- Cooperation with partners producing high quality innovative materials. Collaboration with all specialized universities of the country.
- The desire of people to improve their living conditions and reduce utility costs.

Conclusions. The integrated application of innovative energy-saving and energy-generating solutions, like "BusinessHouse", allows competition not only in certain segments of the construction market, but in general, including the segment of multistorey housing.

The project initiators believe that the competitive advantages will be retained for a long time due to the following reasons:

- The "green tariff" ideology has long-term prospects. This trend is new on the Ukrainian market but already has some support from the government. Besides, specific figures and country commitments are reflected in international documents.
- The cost of utilities is constantly growing, which causes the population to think more and more not only about saving, but also about making money out of new technologies.
- The duration of competitive advantages is guaranteed by the approval of “green tariffs” for a period through 2030 by the Ukrainian National Energy and Utilities Regulatory Commission.
- The findings are clear in light of soaring energy prices, the "BusinessHouse" design is considered to be fast and presents an alternative sustainable economic future for Ukraine.

REFERENCES

1. DBN V.2.6-31:2016. Teplova izolyacia budivel. [Thermal insulation of buildings.] // K.: Minregionbud Ukraïni, 2017. – 35p.
2. DSTU B A. 2.2-12:2015 Energetichna efektivnist budivel [Energy efficiency of buildings. Method of calculating energy consumption for heating, cooling, ventilation, lighting and hot water supply] . – K.: Minregionbud Ukraïni, 2015. – 194 p.
3. DSTU-N B V.1.1-27:2010. Budivel'na klimatologija [Civil Engineering Climatology]. – K.: Minregionbud Ukraïni, 2011. – 123 p.
4. Energy performance of buildings - Calculation of energy use for space heating and cooling, European Committee for Standardization, 2008.
5. Ievgenii Iurchenko, Olena Koval, Mykola Savytskyi and Karim Limam / Economic Feasibility Evaluation of Building Passive // Journal of Energy and Power Engineering Houses Volume 8, Number 6, June 2014 (Serial Number 79) 1047-1053. ISSN1934-8975 USA http://www.davidpublishing.org, www.davidpublishing.com.
6. Savytskyi M., Iurchenko Iev., Koval O., Babenko M. / Development of low-rise energy-efficient construction in Ukraine // ECCE-GSCE-WCCE Internetional Conferens Seismics-2014, #59. Tbilisi, Georgia, 14 p. 5-11 http://www.ecceengineers.eu/news/2014/59_Intl_Conf_Seismic_design_papers.pdf
7. Iurchenko Iev. Study of shell for energy efficient of sustainable low-rise building / Savytskyi M.V., Danishevskyi V.V., Iurchenko Iev., Babenko M.M. // Bulletin of Pridneprovsk State Academy of Civil Engineering and Architecture, 2016, № 3 (216) стр. 10-17. ISSN 2312-2676 http://www.ingentaconnect.com/content/doaj/23122676/2016/00000001/00000003/art00001
8. Energy performance of buildings - Calculation of energy use for space heating and cooling, European Committee for Standardization, 2008.
9. Energetichna strategiya Ukraïni na period do 2030 roku. Prognozuvannya balansiv palivno-energetichnih resursiv : rozporyadzhennya Kabinetu Ministriv Ukraïni [Energy Strategy of Ukraine till 2030. Prediction balance of energy resources]. Cabinet of Ministers of Ukraine of 15 March 2006, no. 145-p, 129 p. (in Ukrainian).
10. Iurchenko Iev.L. Development of the energy saving projects in the buildings of budget organizations on the basis of reinvestment. – Manuscript: 05.13.22 / Iurchenko Iev.L. .– Dnipropetrovsk, 2004. – 180p.
11. Koval O.O. Energy efficiency of low-rise residential buildings of architectural constructive systems. – Manuscript: 05.23.01. / Koval O.O.– Dnipropetrovsk, 2012. – 152p.
12. Iurchenko Iev.L Improved methods of rational design of low-rise residential buildings based on life cycle / Savytskyi M.V., Iurchenko Iev.L., Koval O.O.// Theoretical foundations of civil engineering. – Warsaw: WUT, 2011. vol. №19/ – p. 307-312.
13. Iurchenko Iev.L. Projects to improve energy efficiency of existing residential buildings in Ukraine / Iurchenko Iev.L. // Building, materials sciences, mechanic engineering: Collection of scientific papers Issue№65 – Dnipropetrovs'k, PSAES,, 2012. – p. 677-683. http://pgasa.dp.ua/a/international%20conferences/inovacii/archive/vipusk_65_2012.pdf
14. Iurchenko Iev. Economic feasibility of energy-efficient and passive house construction in Ukraine / Iurchenko Ie.L., Koval O.O., Savytskyi M.V. // Building, materials sciences, mechanic engineering: Collection of scientific papers Issue№68. – Dnipropetrovs'k, PSAES, 2013. - p. 462 – 468. http://pgasa.dp.ua/a/international %20conferences /eco/archive/vipusk_68_2013.pdf

3.4. THE USE OF WIND TURBINES FOR GREEN BUILDING

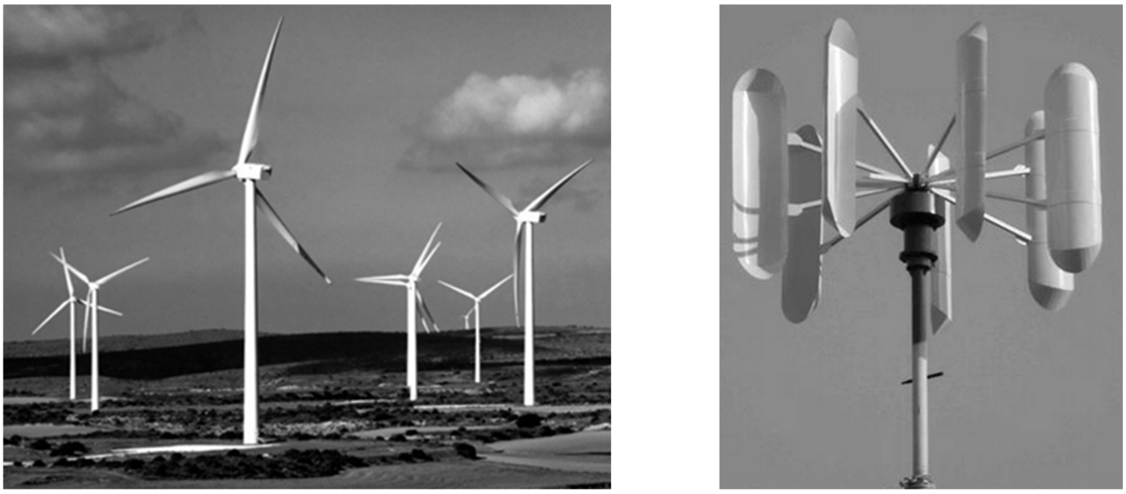
Shatov Sergii, Tytiuk Anatolii, Tytiuk Andriy

The construction of modern settlements and industrial enterprises involves the usage of environmental sources of energy. Wind power engineering is a branch of renewable energy that specializes in the use of kinetic wind energy [1…5, 8]. The wind as a source of energy is an indirect form of solar energy, and therefore refers to the renewable sources of energy. The use of wind energy is one of the oldest known ways of using energy from the environment. Modern achievements in technology and the rapid development of new technologies allow us to approach a significant improvement in performance of wind turbines and their use in various fields of activity, in particular, in construction.

By the middle of the last century wind turbines existed mainly in the form of classical mills. This was due to the fact that windmills could not compete with diesel and hydroelectric power stations in their efficiency. However, until the end of the twentieth century oil significantly increased in price and according to analysts its supplies will last for another 60...80 years. It is necessary to search for alternative sources of energy, in particular wind energy. Zhukovskiy N.E. developed a theory of a wind turbine, on the basis of which high-performance installations capable of receiving energy from the weakest wind could be created. In new projects the achievements of many branches of knowledge are used. However, despite various improvements, the principle of operation of all wind turbines remained virtually unchanged. The only difference is that the wheel with blades rotated under the pressure of the wind and transmitted a rotational moment to the millstones through the transmission system, and now it is transferred to the shaft of the generator, which generates a current directed to the consumer.

A wind turbine installation located on the site where the average annual specific power of the air flow is 500 W/m^2 (air speed is 7 m/s) can convert 175 W/m^2 into electricity. In fact, the total installed capacity of wind power plants in Ukraine is 500 Mw (including the territory of Crimea 87.7 Mw).

Wind turbines are subdivided by such basic signs: axis of rotation; number of blades;material from which the blades are made; screw pitch. Depending on the axis of rotation, the generators are: horizontal; vertical. The most widespread horizontal wind turbines (fig. 1, a), in which the axis of rotation of the turbine is parallel to the ground. This type is called "windmill", whose blades rotate against the wind.



a b

Fig. 1. Wind turbines with the axis of rotation
a - horizontal; b – vertical

The design of the horizontal wind turbines provides an automatic rotation of the main part (in search of wind), as well as turning the blades to use a small wind force. Horizontal wind turbines are advisable to be used for the production of electricity on an industrial scale, they are used to create a system of wind power plants [9, 10].

Vertical wind turbines (fig. 1, b) are less effective. The blades of such turbines are rotated parallel to the surface of the earth in any direction and force of the wind. Since in any direction of the wind, half of the blades of the wind wheel always rotate against it, the windmill loses half its power, which significantly reduces the energy efficiency of the installation. However, vertical wind turbines are easier to install and maintain, as its reducing gear and generator are placed on the ground.

The drawbacks of the vertical generators are: expensive installation, significant operating costs, and a fact that a large area is necessary to install such kind of vertical wind turbine. Vertical wind turbines are used for the needs of small private households.

According to the number of blades (fig. 2, a, c), all installations are divided into two, three, or multi-bladed (50 or more blades). To produce the required amount of electricity, it is not a fact of rotation that is needed, but an output for the required number of revolutions. Each blade (additional) increases the overall resistance of the wind wheel, which makes the output of the generator more difficult. Thus, multiblade plants do start to rotate at lower wind speeds, but they are used when the very fact of rotation matters, as, for example, while pumping water. To generate electricity, wind turbines with a large number of blades are practically not used. In addition, it is not recommended to install a reducing gear on them, because this complicates the design and also makes it less reliable. A promising construction is the spiral form of the wind turbine (fig. 2, b).Such rotor can rotate when the wind direction is at an angle of 60 degrees to its axis.

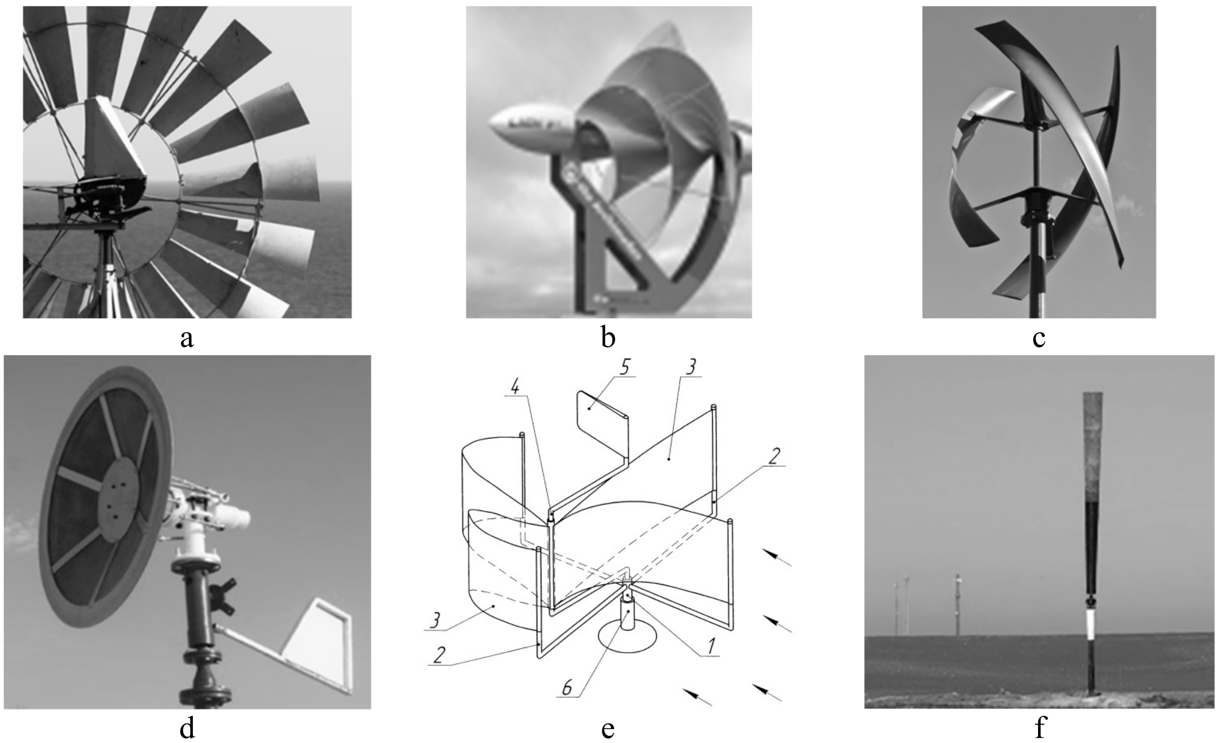


Fig. 2. Types of wind turbines:
a – multi-bladed; b – spiral; c – ortogonal; d, e – sailing;
f – non-bladed swaying

Depending on the material of the blades, wind generators can be: with rigid blades and sailing [11]. Sailing blades (fig. 2, d, e) are much easier to manufacture, and therefore less expensive than rigid metal or fiberglass. However, such savings can result in unforeseen expenses. If the diameter of the wind wheel is 3 m, then at a generator speed of 400... 600 per minute, the tip of the blade reaches a speed of 500 km/h. Given the fact that sand and dust are present in the air, this is an additional factor, even for stiff blades, which require an annual replacement of the anti-rust cover applied at the end of the blades under operating conditions. If you do not update the anti-rust cover, then the rigid blade will gradually lose its performance.

Sailing blades require frequent replacement during the year, especially when there is a significant wind pressure. Therefore, an autonomous power supply, which requires the reliability of the system components, does not consider the use of sailing blades.

The new types of wind turbines include the vertically located Vortex Bladeless device (fig. 2, f), whose appearance represents a swaying cone structure. The principle of operation of the device is based on the phenomenon of the "vortex path of Karman" phenomenon, in which the formation of chains of vortices is observed when gas flows around cylindrical objects. The design of the Vortex Bladeless wind turbine allows to reduce production costs by 53%, reduce maintenance costs by 80%.

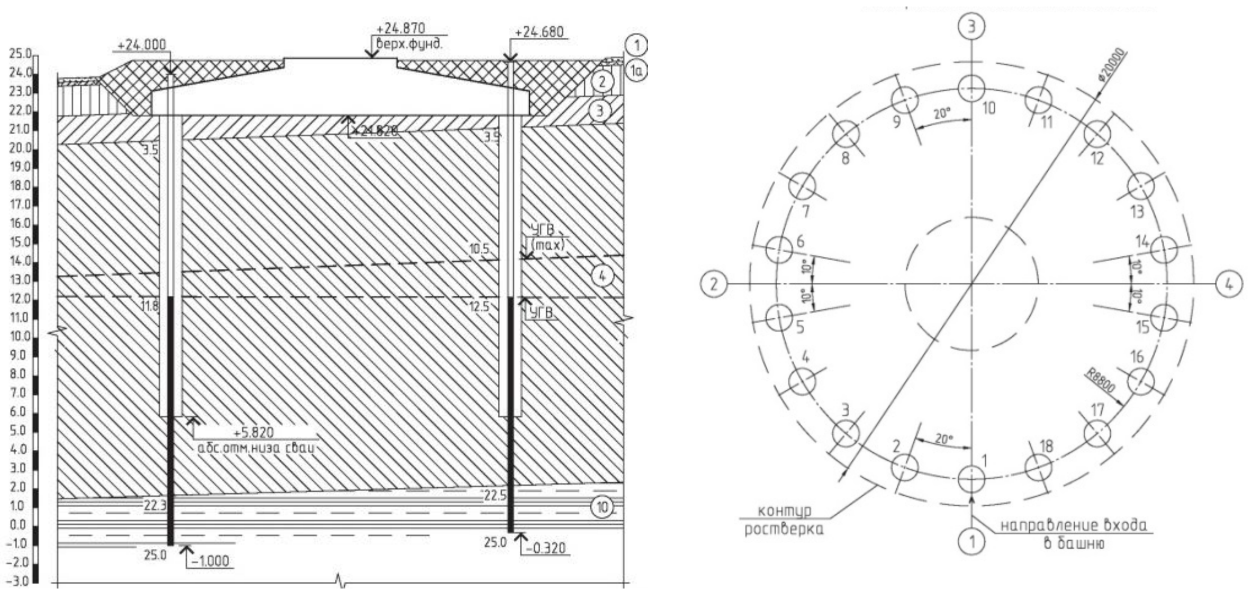
A striking example of the use of wind turbines in Ukraine is the Botiev wind power plant (fig. 3), located near the village of Primorskiy Posad in the Priazovskiy district of the Zaporozhye region [6, 7]. It is one of the five largest wind plants in Europe. The installed capacity of the Botiev wind plant is 200 Mw. The construction was carried out in two stages: in 2012, 30 units were installed, in 2014 - 35. In 2016, the plant generated 608.4 million kWh.

Fig. 3. Wind Turbines of Botiev Wind Plant

Each of the 65 wind turbines Vestas V-112 consists of 11 main node points. The length of the blade is 55 m with a weight of 12 tons, the height of the tower is 94 m, the overall height of the construction is 149 m. The blade makes up to 13 rotations per minute. The total weight of the unit without foundation is 400 tons, the weight of the lower section of the tower is 78 tons. The tower inside is hollow, it contains a staircase and an elevator.

Currently, the "Pridneprovsk State Academy of Civil Engineering and Architecture" is tasked to determine the technical condition of the foundations and compile their passports for each wind turbine. In this regard, at the first stage, the construction documentation was analyzed. The foundation for each turbine was set on 16 piles (fig. 4). The foundation of each wind generator is reinforced with reinforced concrete piles with a diameter of 1.2 m, hammered to a depth of 28 meters.

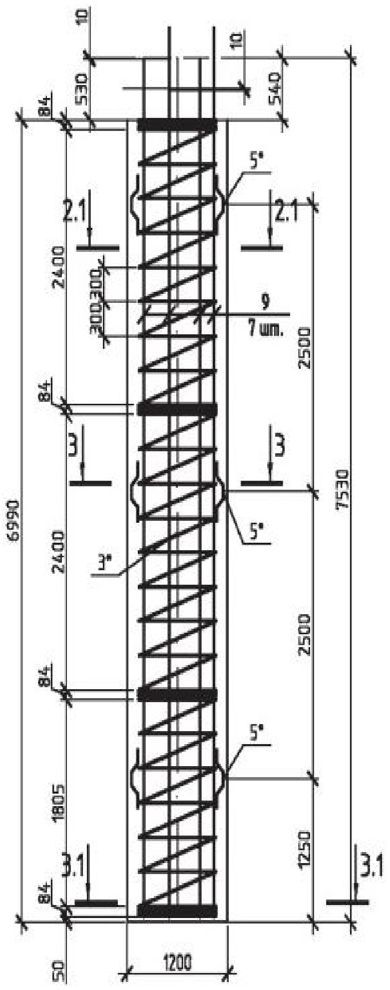
The reinforcing cage of bored piles (fig. 5, a) represents seven vertical reinforcing bars of estimated length, tied together spirally.



a b

Fig. 4. The area of construction of wind electrical installation:
a – sectional elevation; b– scheme of pile field

In the upper part of the foundation there is an anchor (fig. 5, b, c) consisting of the lower, upper parts and 168 bolts on which the lower part of the tower is mounted.



b

a c

Fig. 5. Rebar cage of piles and anchor of the foundation:
a – the cage section; b – general view anchor of the foundation; c – construction

Technical investigation of the foundations will allow to establish the state of its components and substantiate the possibility of continuing safe operation of the wind plants of the Botiev Wind Power Plant.

REFERENCES

1. Neischerpaemaya energiya. Kniga 2. Vetroenergetika [Inexhaustible energy. Book 2. Wind Power] / V.S. Krivtsov, A.M. Olennikov, A.I. Yakovlev. Kharkovskiy natsionalniy aerokosmicheskiy universitet [Kharkiv National Aerospace University], 2004. – 519 p.
2. Analiz osobennostey primeneniya vetrovyih sistem avtonomnogo elektrosnabzheniya na UAS Akademik Vernadskiy [Analysis of the features of the application of wind systems of autonomous power supply to Ukrainian Arctic Station Academician Vernadsky] / V.A.

Dzerginskiy, C.B. Tarasov, C.Yu. Kostyukov, S. Yu. Kremnyov// UkraYinskiy antarktichniy zhurnal [Ukrainian arctic journal], 2008. - № 6-7. 301 – 306. - Available at: www.nbuv.gov.ua/old_jr.

3. Gagach D. K., Maltsev V. K., Kostyukov I. Yu. / Pervaya vetrodizelnaya elektrostantsiya na Taymyire [The first wind-diesel power plant on Taymyire]. Energetik [Energetik], no. 9, 2001. – P. 10–12.
4. Slesarev. V. / Sopernik vetra [Opponent of the wind]// Za rulem [Behind the wheel], no. 1, 2004. p. 24-27.
5. Fateev E. M. / Kak sdelat samomu vetroelektricheskiy agregat. [How to make the wind power unit by yourself]. – Moskov.: 1949. – 65 p.
6. Lyisenko I. Realizatsiya stroitelstva krupneyshey vetroelektrostantsii v Ukraine :Botievskaya VES [Realization of the construction of the largest wind power plant in Ukraine: Botiev Wind Power Plant]. Materialyi tretego Mezhdunarodnogo energeticheskogo foruma «Energoeffektivnost. Energosberezhenie» (11—14 sentyabrya 2013 g.) [Materials of the Third International Energy Forum «Energoeffektivnost. Energosberezhenie» (11—14 of September, 2013.]. - P. 164 – 168.
7. Sezonni ornitologichni osoblivosti teritoriyi Botievskogo vitroparku (Zaporizka oblast) za rezultatami sposterezhen u vesnyani periodi 2013-2014 rokiv [Seasonal ornithological features of the territory of Boteyev wind park (Zaporozhye region) by results of observations in the spring periods of 2013-2014] // Branta [Branta]. — 2014. — no. 17. — P. 19—38.
8. Botievskaya VES [Botiev Wind power plant] // Website wikipedia.org. (https://ru.wikipedia.org/wiki/%D0%91%D0%BE%D1%82%D0%B8%D0%B5%D0%B2%D1%81%D0%BA%D0%B0%D1%8F_%D0%92%D0%AD%D0%A1). Viewed: 31.12.2015.
9. Yak sporudzhuetsya vitroturbina [How the wind turbine is built] (Botievskaya Windpower) // YouTube. 8 of october 2015 (https://www.youtube.com/watch?time_continue=116&v=Wppda-PREyQ).Viewed: 31.12.2015
10. Botievskaya VES [Botiev Wind power plant] (TV and radio channel – «ЮГ» Primorsk) // YouTube. 16 of January 2018 г. (https://www.youtube.com/watch?v=_XmD7Kirawk). Viewed: 31.12.2015
11. Avtomobilnyiy vetrogenerator [The car wind generator]. Website findpatent.ru (http://www.findpatent.ru/patent/237/2375212.html). Viewed: 31.12.2015.

ANALYSIS OF PERSPECTIVE ECOLOGICALLY CLEAN VEHICLES

Kolesnikova Tatiana, Zarenbin Vladimir

Formulation of the problem. In today's world, the state of the environment is the most important task. The impact of road transport on the environment is expressed, mainly, in emissions into the atmosphere of toxic substances generated during the operation of transport. As toxic substances contained in the exhaust gases of internal combustion engines and entering the atmosphere are: carbon monoxide, hydrocarbon compounds, nitrogen oxide, soot, sulfur dioxide and carbon, etc. [1].

Formed in the process of transport operation, harmful substances, lead to negative consequences, such as the greenhouse effect, ecosystem change, the formation of acid rain. The deterioration of the environment has prompted humanity to look for ways to solve the problem.

In an effort to preserve the environment by reducing harmful emissions and lower consumption of non-renewable resources, the world auto industry is making significant progress in the production of environmentally friendly cars.

Environmentally friendly cars are classified into hybrid cars - operating both on gasoline and on electricity; cars that run only on electricity; cars using biofuel; and diesel "green cars". Each type has its advantages and disadvantages.

Main text. The solution to this problem associated with the operation of road transport is as follows: reduce emissions of toxic substances with the exhaust gases. To reduce emissions of toxic substances, it is necessary to develop fundamentally new types of motor vehicles - "Green car" - a car that uses less oil and produces fewer emissions. Use alternative energy sources, and also improve piston internal combustion engines.

In an effort to preserve the environment by reducing harmful emissions and lower consumption of non-renewable resources, the world auto industry is making significant progress in the production of environmentally friendly cars.

Environmentally friendly cars are classified into hybrid cars - operating both on gasoline and on electricity; cars that run only on electricity; cars using biofuel;

and diesel "green cars". Each type has its advantages and disadvantages.

Cars of this type are equipped with two engines: an internal combustion engine and an electric motor. Hybrid cars are divided into three types:

1. Parallel - the gasoline engine and the electric motor work together (for example Porsche Panamera S Hybrid).

2. The serial - petrol engine either directly powers the electric motor, or charges the batteries (for example Chevrolet Volt).

3. Serial-parallel - depending on the mode, the system works both sequentially and in parallel (for example Toyota Prius). Engineers from Toyota have created the system Hybrid Synergy Drive (hybrid synergic drive). At medium and constant speeds, the engine transfers some of the energy to the front wheels through the planetary gear. The remaining energy is transferred to the generator, which in turn gives up some of the energy to recharge the battery and the part to the electric motor. When overtaking, lifting and acceleration, the recharging of the battery stops and all current is directed to the motor. At low speeds, the car works like an electric car. All these processes are controlled by a computer.

All three types of hybrids use the regenerative braking process to save kinetic energy - the gasoline engine turns off and the electric motor switches to the current generation mode and returns the energy to the battery. All three types have small gasoline engines and, therefore, produce far fewer pollutants than a standard car. But their power is also less - 60-90 horsepower. To overcome this power gap, hybrid cars are built from lightweight materials, such as carbon fiber and aluminum. Hybrid cars are also more aerodynamic, which reduces air resistance. These factors combine to give an efficient form to the car, which receives excellent fuel economy and reduces environmental pollution. For example, the hybrid Toyota Prius produces 90% less pollutants than similar non-hybrids.

In Ukraine, hybrid cars have become widely available, and they can be found in all price ranges. Volvo released the world's first diesel hybrid Volvo V60 Plug-in.

Ecological transport of a hybrid type has the main advantage - it is fuel economy; on average, its consumption is less by 20-25% than in traditional machines.

This is achieved through full automatic control of the operating mode of the engine system using an on-board computer. For example, the motor itself is turned off while the car is stopped, with the possibility of continuing driving without starting it, solely on the energy of the battery. In general, the hybrid engine always works in the optimal mode, so as to save. In the city, for example, he works most of the time as an electric car. At the same time, all technical parameters and parameters of a conventional car in hybrids are either kept or improved. And this is the power, speed, ability to rapid acceleration, etc. The second plus of hybrids: a decrease in the consumption of carbon fuels positively affects the ecological component of such cars. Reduction of carbon dioxide and other harmful substances into the atmosphere occurs just due to rational fuel consumption or a complete stop of gasoline consumption by the engine (when driving on electric traction). The third advantage - the ability to drive a certain time without fuel on the charge of electric batteries (an average calculation of 30 km). You can distinguish the quiet operation of the engine, if the car stands still, which is achieved through the operation of the electric motor.

Among the shortcomings of hybrid cars are the following: limited battery life, expensive replacement of batteries, batteries are self-discharging, they also can not withstand a large temperature drop (they have a small range of operating temperatures). The price of a hybrid car is higher by 30% because of the complexity of the unit (if the price segment is above the average), repair is more expensive and more complicated, special service centers are not developed. A large mass of such cars due to the batteries and the electric motor (s). The disadvantages can also be attributed to the fact that although the total fuel consumption drops to 50% (for cars that mostly move in the urban cycle), but for long trips along the route the advantages of hybrids come to naught.

Unlike hybrid cars, electric vehicles are driven by an electric motor powered by rechargeable batteries. Electric motors have several advantages over internal combustion engines.

Electric cars that only rely on the battery are one of the most rational solutions today [2,3].

To date, in the face of the ever-growing demand for electric vehicles, more and more companies are engaged in their development and production [4]. At the same time, they can be divided into two categories:

- firms that develop and produce only electric vehicles: Tesla Motors, REVA and Faraday Future;

- Manufacturers producing electro-versions based on their traditional cars: Renault, Nissan, BMW and others.

Such ecological types of transport have the following advantages: ecological compatibility; the best efficiency of the electric motor (85-95%); simple device, less noise. The electric motor provides a smooth ride and a stronger acceleration, requiring less maintenance than the ICE.

At the same time, electric cars have the following disadvantages:

- high toxicity of electrochemical battery cells in case of damage;

- high cost of the storage battery;

- the effect of environmental conditions (temperature) on the capacity of batteries;

- a large mass of the car due to the massiveness of the battery;

- Underdeveloped infrastructure of charging stations;

- a small mileage from one battery charge - an electric car will be able to travel about 2 times less than a normal car without recharging .;

- by several orders of magnitude more "refueling" time than cars with ICE.

As an alternative to hydrocarbon fuels, alternative fuels are increasingly used for cars.

The most common type of biofuel is ethanol - ethyl alcohol, used to produce motor fuel in return for gasoline. Ethanol is produced from various materials, biomass, such as corn, sugar cane and wood waste. Most car models can use the E10, which consists of 10% ethanol and 90% gasoline, without any changes in the engine. Other similar mixtures consist of 20% and 30% of E20 and E30, respectively. The most environmentally friendly ethanol fuel - E85, consists of 85% ethanol and 15% gasoline. The use of E85 as a transport fuel significantly reduces harmful emissions of exhaust gases. Ethanol is a less "energy-dense" energy source than gasoline. The mileage of cars running on the E85, per unit volume of fuel is approximately 75% of the mileage of standard vehicles.

Diesel engines are about 30 percent more efficient than gasoline engines.

Biodiesel is a fuel based on animal and vegetable fats and microbial origin. Biodiesel further enhances the benefits of diesel fuel by reducing exhaust emissions. B20 - a twenty percent mixture of biodiesel and conventional diesel - reduces hydrocarbon emissions by 20% and carbon monoxide and particulate matter by 12%. It is non-toxic and biodegradable. This means that the diesel engine will produce about 30 percent more horsepower, or give 30 percent fuel economy (or 30 percent less carbon dioxide emissions).

One of the promising areas for creating an environmentally friendly car is the possibility of using hydrogen as a fuel for an internal combustion engine (ICE) in hybrid engines or fuel cell vehicles in which there is no internal combustion engine. As a source of energy, hydrogen will be used in it, which is safe and environmentally friendly: the only release into the atmosphere will be water vapor [5].

Hydrogen is absolutely environmentally friendly and inexhaustible alternative fuel, which can be obtained from water.

Hydrogen can be used as fuel in a conventional rotary internal combustion engine, since in it the exhaust manifold is significantly removed from the intake manifold. A conventional ICE for working on hydrogen is not suitable, since hydrogen is easily ignited by the high temperature of the exhaust manifold. When hydrogen is used in the engine, engine power is reduced to 82% -65% compared to gasoline.

If small changes are made to the ignition system, engine power is increased to 117% in comparison with the gasoline analog, but then the output of nitrogen oxides will significantly increase because of the higher temperature in the combustion chamber and the likelihood of flaring of valves and pistons increases with prolonged operation at high power. In addition, hydrogen at temperatures and pressures that are created in the engine is able to react with engine materials and lubricant, resulting in faster wear. Hydrogen does not produce greenhouse gas emissions when used in fuel cells, it produces only nitrogen oxides during combustion.

If we consider a hybrid car working on hydrogen, in which hydrogen does not emit any pollutants in pure oxygen under combustion, this car is promising from the ecological point of view. But in a combustible form, hydrogen at room temperature and normal pressure is a gas. This causes difficulties in storing, carrying and transporting it. A particularly complex problem is the design of safe cylinders or other tanks for hydrogen-fueled vehicles [6, 7].

In cars that use fuel cells, the main advantage is that the chemical energy in them directly turns into electrical [8]. They are noiseless and without the release of harmful substances into the atmosphere. Therefore, the use of fuel cells in cars is a very promising technology in terms of environmental protection. The shortcomings of fuel cell vehicles include: high production costs, primarily due to the presence of platinum parts, an increase in the cost of such vehicles due to hydrogen tanks, the difficulty of selling a network of hydrogen filling stations.

Proceeding from the analysis of environmentally friendly cars, we can conclude that electric vehicles have disadvantages - the main ones, this is a significant price, about twice the cost of cars with ICE of the same class, plus a poorly developed infrastructure. Fuel cell engines are the only acceptable ecological energy with a huge future. However, the biggest obstacle for hydrogen fuel car manufacturers is the cost of existing technologies due to the presence of platinum as a catalyst in the fuel cell. The maximum mileage of a car on hydrogen fuel cells is less than the mileage of a car with hydrocarbon fuel.

These disadvantages are deprived piston internal combustion engines (ICE). Undoubtedly, electric cars are the nearest future, but also the developers of ICE are constantly improving the engines.

Perfection of piston ICEs is carried out in various ways, such as improving the organization of the working process (prechamber-flare ignition, bundle charge in the combustion chamber, Miller and Atkinson methods, etc.), the use in partial regimes of a variable compression ratio and the deactivation of a part of the cylinders.

To date, many leading companies and organizations in Germany, the United States, Australia, Russia and Ukraine are developing fundamentally new non-traditional engine designs, for example, in Ukraine at the Road and Automotive Institute under the guidance of prof. Mishchenko NI developed and tested a number of experimental single-cylinder unpiston-rod engines with a crank-rocking mechanism (CMC) working volume of 0.075 liters [9]. A frictionless engine with a crank-link mechanism with variable compression ratio was developed. According to the results of the tests, the fuel economy of unpiston-rod engine with a crank-rocking mechanism is 20% higher than that of a classic ICE with a crank mechanism. The analysis of the unpiston-rod engine with a crank-rocking mechanism shows that in this engine, in addition to the possibility of increasing the effective efficiency due to small mechanical losses, it is structurally simpler to implement a modular cylinder shutdown, which leads to a 40% fuel economy. The idea of implementing the disconnection of the cylinders by stopping the piston, in the unpiston-rod engine belongs to prof. Mischenko NI, who developed a mechanism for stopping the piston on an unpiston-rod engine with a crank-rocking mechanism [9].

The foregoing points to the necessity and feasibility of investigating the economic efficiency of a unpiston-rod engine in terms of its application in road transport.

Conclusions. Proceeding from the analysis of promising environmentally friendly cars, it can be concluded that special attention should be paid to the introduction of fuel cell technologies. Hydrogen is the only acceptable ecological energy with a huge future. But for now this prospect is near future. At present, sufficient fuel efficiency can be achieved by improving the piston-free piston ICE with a crank-link mechanism, by stopping the pistons and applying a variable compression ratio in partial modes. Especially technologically, such an engine is easier to implement in metal (80% of the details on the manufacture of this engine are suitable for the classic engine).

REFERENCES

1. Golokhvast K.S, Chernyshev V.V, Ugay S.M. Motor vehicle emissions and human ecology (literature review) // Human Ecology. 2016. № 1. P. 9-14. Golokhvast K. S., Chernyshev V. V., Ugay S. M. Car Exhausts And Human Ecology (Literature review). Ekologiya cheloveka [Human Ecology]. 2016, 1, pp. 9-14.
2. Matskerle, Y. Modern economical car / Y. Matskerle; trans. with Czech. V.B. Ivanova; Ed. A.R. Benedictova. - M .: Mechanical engineering, 1987. - 320 p.
3. Stroganov, V. I. Improving the performance characteristics of electric vehicles and cars with a combined power plant: dis. ... Dr. techn. Sciences / Stroganov V. I. -M., 2015. - 356 p.
4. http:// www.avtoaziya.ru/component/tags/tag/ehlektromobili.html
5. http:// www.news.eizvestia.com.
6. Ramensky A. Y., Shelisch P. B., Nefedkin S. I.. The use of hydrogen as a propellant for automotive internal combustion engines. History, Present and Prospects International Scientific Journal "Alternative Energy and Ecology" АЭЭ №11 (43), 2006, 63-70c.
7. Galeev A.G., Problems of Ensuring the Safety of Stand Testing of Propulsion and Power Plants on Hydrogen Fuel, International Scientific Journal "Alternative Energy and Ecology" AEE № 11 (43), 2006, 23-27c.
8. http://www.donaukurier.de / nachrichten / auto / Toyot a-weiht - Montagestrasse - fuer Brennstoffzellenautoein; art59,3021605 09/28/2015
9. Mischenko N. I. Automobile engines with cylinder shut-off: structures, analysis / NI. Mishchenko, T. N. Kolesnikova, V. L. Suprun, A.G. Podlysni // Visnyk SevNTU: zb. sciences. Ave Vip. 122/2011. Series: Mechanical Engineering for transport. - Sevastopol, 2011.

3.6. STUDY OF THE PANEL-RADIATOR HEATING SYSTEM FUNCTIONING WITH THE INTENSIFICATION OF THE RADIATIVE HEAT TRANSFER OF THE HEATING PANEL EXTERNAL LAYER

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Human health and well-being depend on sanitary and hygienic conditions, as well as on the parameters of indoor climate of the premises of residential, public and industrial buildings. Consequently, our main goal is to create good ambient conditions in the building.

The microclimate of the room is climate of the internal environment of the premises, which is defined by acting on a human body combinations of air and enclosing structures temperature, humidity and air velocity parameters [1].

We can consider as comfortable those conditions under which a person doesn't feel discomfort (overheating or overcooling). The thermal comfort is a subjective feeling perceived by a person under the complex influence of the microclimate parameters. From a technical point of view, the most important for the supporting of the microclimate conditions are the parameters that can be changed by life-support systems all year round. Particularly, the factors related to the feeling of warmth are of interest.

Life-support systems of buildings allow to regulate the temperature of the internal air t_{int} (° C), relative humidity, φ_h (%), velocity, υ_{int} (m / s) and also to maintain the necessary parameters of the microclimate for living and high labor productivity at workplaces.

The basis for choosing the parameters of the microclimate in the room are the conditions of human life and the requirements of the technological process.

Our task is to provide a normal temperature component of the microclimate inside the premises, with a maximum reduction in the cost of energy consumption for heating. This is an actual scientific and practical task of the present.

The correct heat transfer case can be obtained only in models, calculated according to the rules of the simulation, which ensure the similarity of the phenomena in the sample and model. In this case, the necessary and sufficient conditions of thermal similarity are the following [2, 3, 4]:

1) geometric similarity;

2) similarity of temperature conditions;

3) the similarity of physical properties at similar points in the model and sample (the constancy of the relative density, viscosity coefficients, etc.);

4) the similarity of temperature fields at the boundaries;

5) the identity of the determinant numbers values of similarity (similarity criteria). Hereby, an equality of the numbers of similarity is sufficient to establish in any one similar cross section.

The exact realization of all modeling conditions is quite complicated and can only be accomplished in rare cases. Therefore, a method for the approximate modeling of heat transfer phenomena in the equipment was developed. Approximate modeling was possible due to special properties.

The first condition. Geometric similarity can always be achieved by constructing a model, which represents an exact copy of the sample. Of course, its not relevant to the external form of the test unit and the internal configuration of the wires, which conduct electric current.

The second condition. The similarity of the conditions for the entry of an electric current also can be accomplished by arranging the input area geometrically similar to the entrance region of the sample. Basing on this stability property, it is quite enough that the conditions of the electric current at the entrance to the model and sample were similar to each other.

The third condition. The similarity of physical properties when simulating thermal devices is the most difficult condition to be achieved. According to this condition, it is necessary that at all similar points of the sample and model, the relation of the corresponding physical properties is constant. If there is the electric current in the sample.

When temperature changes, the values of physical properties change too. In such cases, in order to satisfy the conditions of similarity, it is necessary that the physical properties in the model and in the sample change in the same way. However, it is impossible to carry out this similarity in its entirety. Therefore, under the forced motion of an electric current, the third condition of similarity is observed only approximately, carrying out in the model an isothermal process of motion (corresponding to some average temperature of the working fluid in the sample).

Fourth condition. It is also very difficult to achieve the full similarity of the heating panels at the borders. Therefore, an approximate method of local thermal modeling is usually used. The peculiarity of this method is that the similarity of the heating panels is ensured only in the area where the heat transfer examination is carried out, and the study is carried out under such conditions, when the conditions of mechanical similarity in this place are satisfied.

Fifth condition. The condition of the identity for determining the numbers of similarity in the sample and the model, as well as the third, can be fulfilled only approximately.

Currently, simulation is one of the main methods of scientific research and it is widely used in many fields of science and technology. Simulation as a method of scientific research, as a method of technical device performance assessment and its functioning in reality, best corresponds to the demands of practice. In this regard, its potential is far from being fully realized. Especially broad perspectives are expecting from the model method applying to chemical technology and engineering.

A scheme of an experimental stand was designed to simulate the functioning of electric heating panels using cement-sand and cement-sand granite mortars with a different granite filler fraction, as shown in Fig. 1

The stand consists of four sections. In the first we have used cement sand mortar in a proportion of 1/4 (1 kg of cement, 4 kg of sand). In the second - cement sand mortar with an admixture of granite filler with a fraction of 0,63 mm in a proportion of 1/1/3 (1 kg of cement, 1 kg of granite filler, 3 kg of sand). In the third - cement-sand mortar with an admixture of granite filler with a fraction of 1,25 mm in a proportion of 1/1/3 (1 kg of cement, 1 kg granite filler, 3 kg of sand), in the fourth -

cement-sand mortar with an admixture of granite filler with a fraction of 2,5 mm in proportion 1 / 1/3 (1 kg of cement, 1 kg of granite filler, 3 kg of sand). There are glass partitions between sections with dimensions 570x5x30.

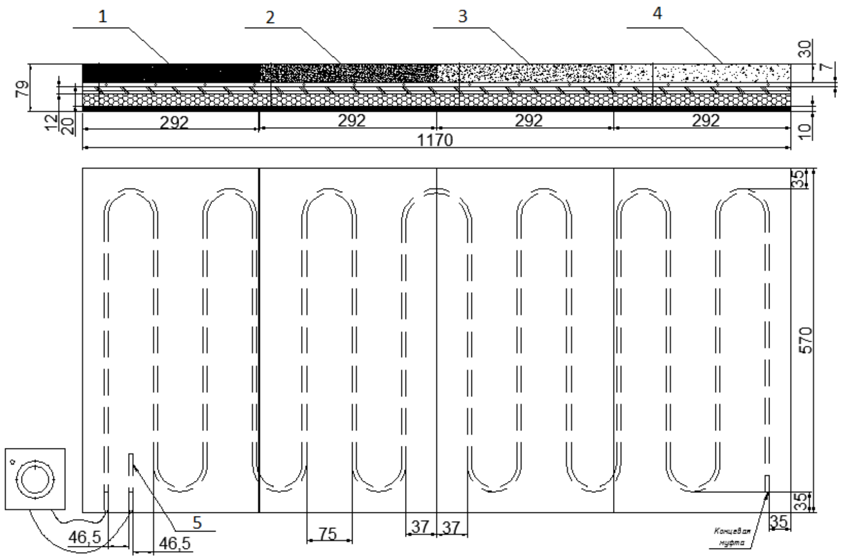

Fig. 1. Scheme of an experimental stand for the simulation of functioning of electric heating panels:

1 - cement-sand mortar, electric cable, reinforcement net, polystyrene; 2 - cement-sand-granite mortar (granite fraction - 0,63 mm), electric cable, reinforcement net, polystyrene; 3 - cement-sand-granite mortar (granite fraction - 1,25 mm), electric cable, reinforcement net, polystyrene; 4 - cement-sand-granite mortar (granite fraction – 2,5 mm), electric cable, reinforcement net, polystyrene; 5 - temperature sensor.

The electrical connection scheme of the stand is represented in Fig. 2.

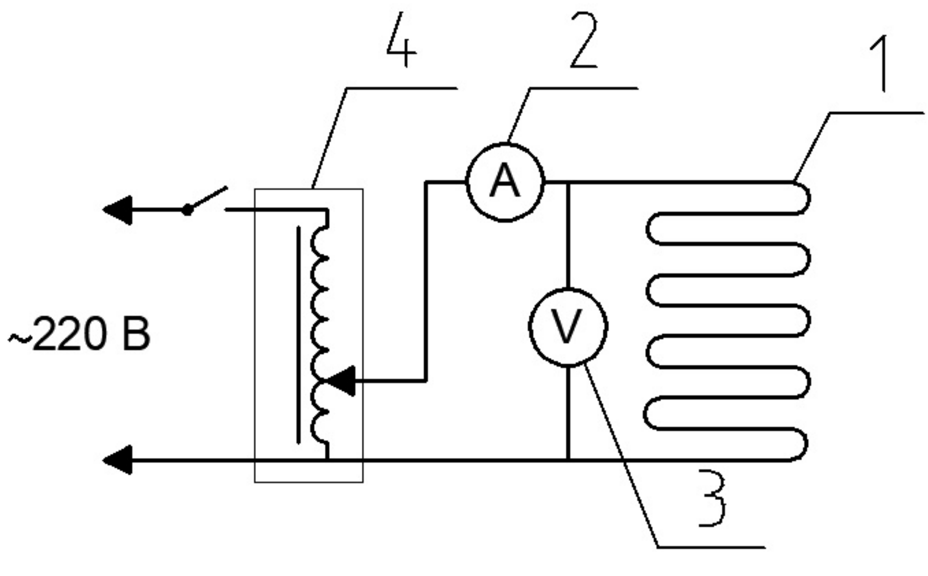

Fig. 2 The electrical connection scheme of the stand:

1 – electric cable Devi; 2 – ammeter; 3 – voltmeter; 4 – autotransformer.

The next equipement was used for the research: barometer, thermometer, pyrometer, ammeter, voltmeter and autotransformer.

The following order of the research was defined:

1. Fix the indications of barometer and thermometer;
2. Connect the autotransformer to the ammeter and voltmeter;
3. Connect ammeter and voltmeter to the cable of electric heating;
4. Turn the pointer of the voltage indicator on the autotransformer so that it shows 60 V;
5. Fix the indications showing by a voltmeter and ammeter;
6. Every half hour (30 min.), measure the temperature on the surface of the panels, using a pyrometer;
7. If the indicated values of the pyrometer do not change, then fix the temperature data in the table;
8. Increase the voltage to 140 V (as written in paragraph 3);
9. Repeat p.4-p.6;
10. Increase the voltage to 220 V (as it is written in paragraph 3);
11. Repeat paragraphs 4 - 6;
12. Plot a graph of the temperature dependence of the voltage for all panels;
13. Set the stand upright and repeat paragraphs 4 to p.12;
14. Install the stand so that the heating surface was directed downwards and repeat paragraphs 4-12;
15. Calculate the heat output from the panels in different positions of the stand;
16. Compare data obtained from tables, graphs, and calculation of heat transfer;
17. Find out in what position the panel is heated more.

The results of simulation studies of floor heating are summarized in Table 1.

An example of the disposition of the heating panel for the floor heating simulation is shown in Figure 3.

Table 1. The results of simulation studies of floor heating

Simulation of floor heating	Indications of ammeter	Panel №1	Panel №2	Panel №3	Panel №4
Pressure	101325 Pa				
Indoor air temperature	22 ºC				
Heating temperature at a power of 60 V	0,2 A	23,2 ºC	23,3 ºC	23,3 ºC	23,4 ºC
Heating temperature at a power of 140 V	0,27 A	27,2 ºC	27,5 ºC	27,6 ºC	27,8 ºC
Heating temperature at a power of 220 V	0, 37 A	34 ºC	34,7 ºC	35 ºC	35,3 ºC

Fig. 3. An example of the disposition of the heating panel for floor heating simulation

The results of simulation studies of wall heating are summarized in Table 2.

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Table 2. The results of simulation studies of wall heating

Simulation of wall heating	Indications of ammeter	Panel №1	Panel №2	Panel №3	Panel №4
Pressure	101325 Pa				
Indoor air temperature	22 ºC				
Heating temperature at a power of 60 V	0,2 A	22,7 ºC	22,8 ºC	22,9 ºC	23 ºC
Heating temperature at a power of 140 V	0,27 A	27 ºC	27,2 ºC	27,4 ºC	27,6 ºC
Heating temperature at a power of 220 V	0, 37 A	34,4 ºC	34,8 ºC	35,2 ºC	35,6 ºC

An example of the disposition of the heating panel for the wall heating simulation is shown in Figure 4.

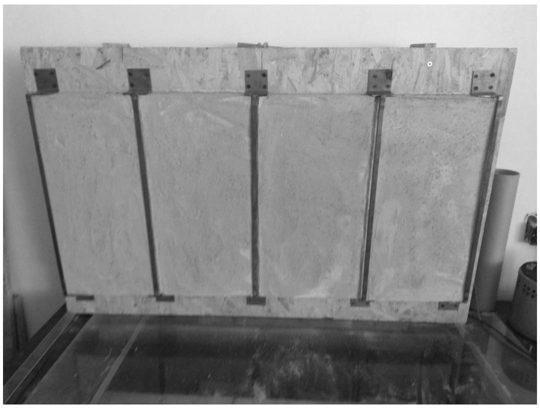


Fig. 4. An example of the disposition of the heating panel for wall heating simulation

The results of simulation studies of ceiling heating are summarized in Table 3.

Table 3. The results of simulation studies of ceiling heating

Simulation of ceiling heating	Indications of ammeter	Panel №1	Panel №2	Panel №3	Panel №4
Pressure	101325 Pa				
Indoor air temperature	22 ºC				
Heating temperature at a power of 60 V	0,2 A	23,3 ºC	23,4 ºC	23,4 ºC	23,5 ºC
Heating temperature at a power of 140 V	0,27 A	26,8 ºC	26,9 ºC	27 ºC	27,3 ºC
Heating temperature at a power of 220 V	0, 37 A	32,9 ºC	33 ºC	33,2 ºC	33,9 ºC

An example of the disposition of the heating panel for the ceiling heating simulation is shown in Figure 5.

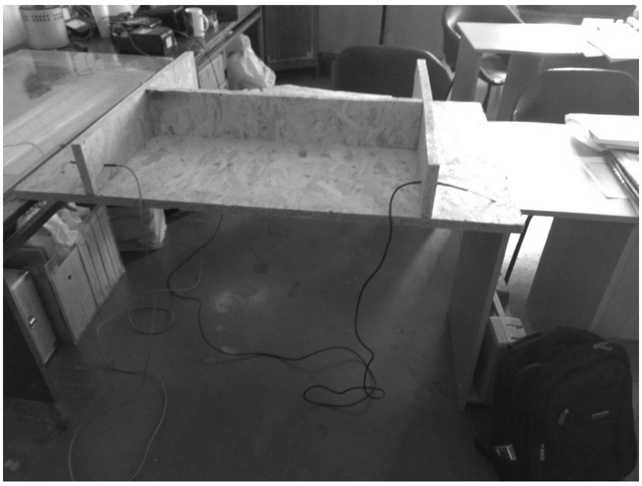


Fig. 5. An example of the disposition of the heating panel for the ceiling heating simulation

Then we calculated the power of electric panels ($\alpha_в$ for calculation of floor heating = 7,3 ($\frac{W}{m^2 \cdot {}^oC}$), $\alpha_в$ for wall heating calculation = 8,6 ($\frac{W}{m^2 \cdot {}^oC}$), $\alpha_в$ for calculation of ceiling heating = 5,8 ($\frac{W}{m^2 \cdot {}^oC}$)), using expression $Q = \alpha_в \cdot F - \left(t_{ср}^{пан} - t_в\right)$. After that, using a formula $N = I - U$, we calculated the power under ideal conditions. Using expression $N = \frac{Q}{\eta}$ we calculated the rate of efficiency of all panels in each disposition. All calculations are summarized in Table 4.

Table 4. Summary table of results

	For floor heating simulation				For wall heating simulation				For ceiling heating simulation				Indications of voltmeter, V	Indications ammeter, A
Fraction of granite dust, mm	Sand	0,63	1,25	2,5	Sand	0,63	1,25	2,5	Sand	0,63	1,25	2,5		
Q, W	1,31	1,42	1,42	1,53	09	1,03	1,16	1,29	1,13	1,22	1,22	1,31	60	0,21
Q, W	5,65	6,02	6,13	6,3	6,45	6,71	6,96	7,22	4,18	4,26	4,35	4,61	140	0,27
Q, W	13,14	13,91	14,24	14,56	16,05	16,51	17,03	17,48	9,44	9,57	9,79	10,31	220	0,37
n, %	10,4	11,3	11,3	12,2	7,2	8,2	9,2	10,2	9	9,7	9,7	10,4	60	0,21
n, %	15	15,9	16,2	16,7	17,1	17,8	18,4	19,1	11	11,3	11,3	12,2	140	0,27
n, %	16,1	17,1	17,5	17,9	19,7	20,3	20,9	21,5	11,6	11,8	12	12,7	220	0,37
$\tau_{вн}$, °C	22													
N, W	12,6	12,6	12,6	12,6	12,6	12,6	12,6	12,6	12,6	12,6	12,6	12,6	60	0,21
N, W	37,8	37,8	37,8	37,8	37,8	37,8	37,8	37,8	37,8	37,8	37,8	37,8	140	0,27
N, W	81,4	81,4	81,4	81,4	81,4	81,4	81,4	81,4	81,4	81,4	81,4	81,4	220	0,37

Then we plotted graphs of heat transfer dependence Q (W) from the temperature t (°C) using calculations and Table 4. The graphs for different filler fractions are presented below.

Conclusions

Experimental research of the panel-radiator heating system functioning with the intensification of the radiative heat transfer of the heating panel external layer has been carried out.

2. The results of experimental research have been treated.

3. We plotted the graphs of heat dissipation difference from different mortar and in different dispositions of panels during simulation of heating. The greatest heat

dissipation was fixed on a part of the plate containing granite filler with a fraction of 2,5 mm, particularly:

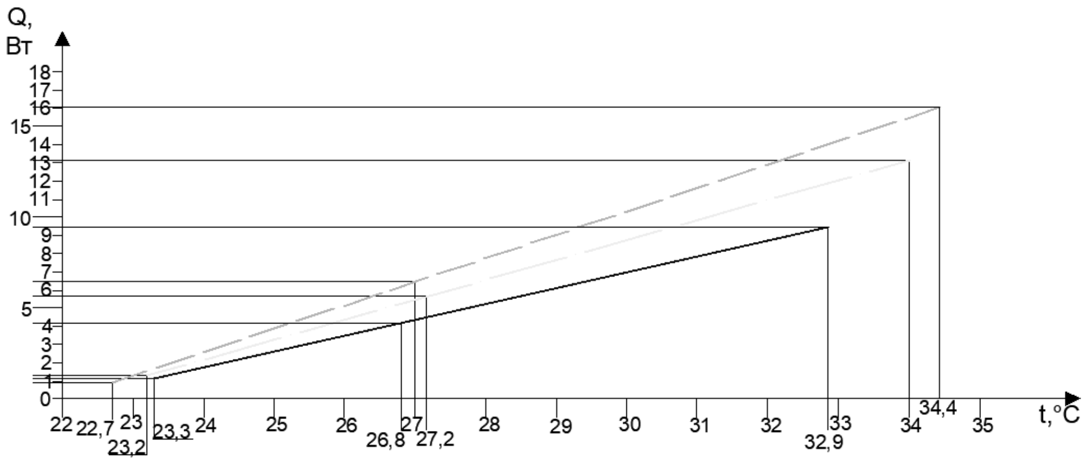


Fig. 6. Heat dissipation of the heating panel using a cement-sand mortar

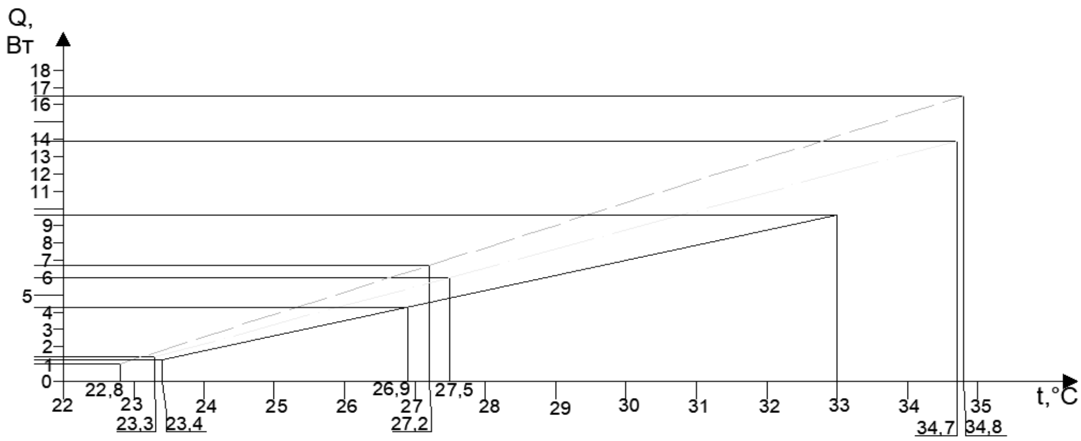


Fig. 7. Heat dissipation of the heating panel using a cement-sand-granite mortar (granite fraction of 0,63 mm)

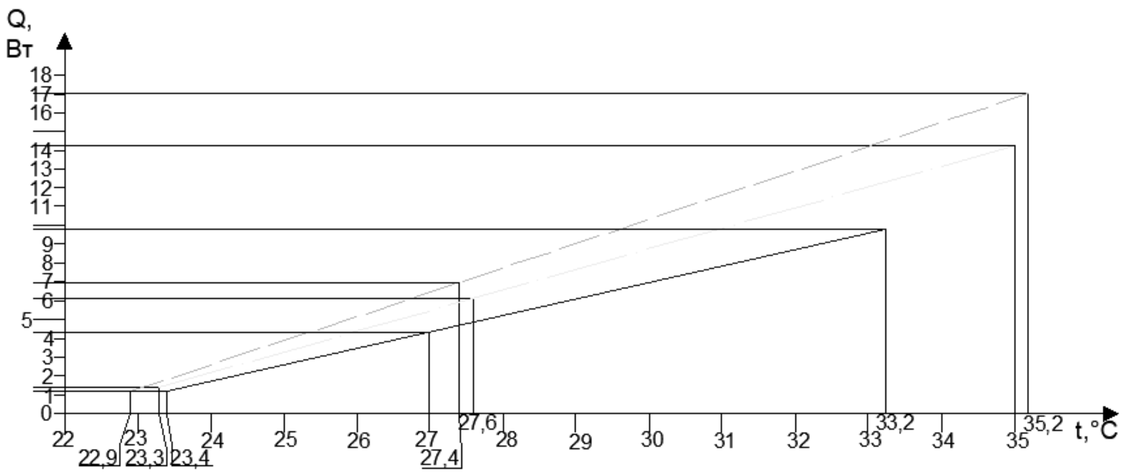


Fig. 8. Heat dissipation of the heating panel using a cement-sand-granite mortar (granite fraction 1,25 mm)

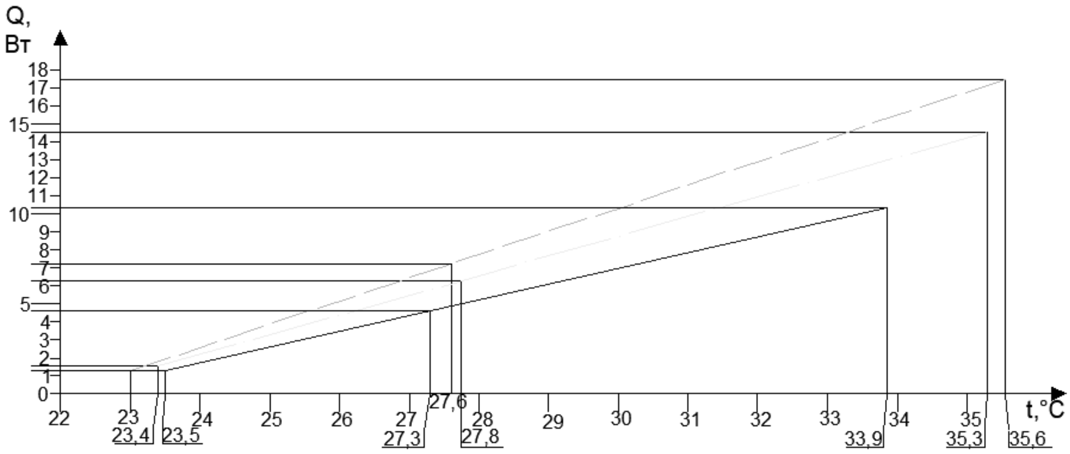


Fig. 9. Heat dissipation of the heating panel using a cement-sand-granite mortar (granite fraction 1,25 mm)

- for the wall $Q_{n.}$= 17,48 W;
- for the floor $Q_{n.}$= 14,56 W;
- for the ceiling $Q_{n.}$= 10,31 W;

as the highest efficiency was fixed at the position of wall simulation (for wall simulation η = 21,5%, for simulation of ceiling η = 12,7%, for floor simulation η = 17,9%), so to calculate the number of heating electric wires we will first of all use this position of the heating panel, then the position of floor heating simulation.

REFERENCES

1. State sanitary norms 3.3.6.042-99 «Sanitary norms of the microclimate of industrial premises», State construction service of Ukraine, 1998г.-78 с.
2. Shchekin, R.V., Korenevsky S.M., Bem G.E. and others "Reference book on heating and ventilation" (4th edition, revised and supplemented). K .: Budyvelnich, 1976. - 352 pp.
3. Bogoslovsky V.N. and others "Heating and Ventilation": Textbook for high schools 2 nd ed. revised and supplemented - Moscow: Stroyizdat, 1980. - 295 pp.
4. "Heating and ventilation of residential and civil buildings": Design: reference book / G.V. Ruslanov, M.Y. Rozkin, E.L. Yampolsky - K.: Budivelnyuk, 1983. - 272 pp.
5. Air, sanitary and climatic balance of the region / V. O. Petrenko, A. O. Petrenko, K. B. Dikarev, X. Brunetaud. – Dnipro: SP Blyzniuk, 2016. – 120 p.
6. Petrenko A.O., et al. Development of an energy-efficient hybrid heating system of a cottage // Construction. Material science. Mechanical engineering. Series: Power engineering, ecology, computer technologies in construction. - 2015. - No. 84. - P. 151-155.
7. Petrenko A.O. Optimal microclimate conditions ensuring taking into account the simulation of the thermal regime of the premises // Construction. Material science. Mechanical engineering. Series: Creation of hi-tech ecocomplexes in Ukraine on the basis of the concept of balanced (sustainable) development. - 2013. - No. 68. - P. 266-271.

MODIFICATION OF HEMPCRETE BINDER BY ZEOLITE ADDITIVE

Gregorová Valéria, Ledererová Miriam, Štefunková Zuzana

Given the risk of exhaustion of non-renewable resources, society is increasingly focusing on the use of sustainable resources. Unlike many synthetic materials, natural materials do not contain any harmful chemicals. When properly installed, many of them are vapour-permeable, which has a significant impact on the health of buildings and its inhabitants as well. Natural materials that are used in construction: stone, wood, clay, burnt clay, animal hair, straw, hemp, lime, cane, etc. Throughout the centuries, even the millennia, they were used by humans, even animals in order to provide them warmth and shelter. With increasing awareness of the threats associated with excessive dependence on fossil fuels and other non-renewable resources, and with the negative side-effects of synthetic materials, there has been a growing interest in these natural materials.

Renewable resources include a hemp plant. This plant with its growth rate and requirements puts minimum demands on cultivation and, within a short time, meets collection and processing requirements for various purposes.

Hempcrete, as a building material, has a very low energy consumption compared to conventionally used materials in its preparation, processing and construction itself. Buildings built from hemp plant in combination with suitable finishes have a very pleasant and healthy indoor climate. Also, they require a considerably reduced amount of energy compared to buildings from commonly used materials to maintain indoor comfort.

Hempcrete consists of chopped, compressed stems of technical hemp mixed with a lime-based binder. It is a natural, healthy, sustainable, local building material with minimal absorbed energy, which can be said to be more than just a zero carbon footprint material. The carbon dioxide consumed by hemp plant during growth is bound in the woody stalk, and when it comes to the end of hempcrete durability, the hempcrete itself can be used as a fertilizer instead of being deposited in a landfill. It is an excellent insulating material with a high heat accumulation and an ever-increasing amount of evidence shows that it behaves even better than in the model situation when designing. When the hempcrete is used with the right plaster, it represents a diffusion open structure that provides control of moisture in the indoor climate.

Hempcrete is mainly attractive for self-help builders because it is a way of construction that requires minimal technological equipment and little mechanization. However, the construction is relatively laborious and with the lack of understanding or weak skills of builders there are potential problems or even complete failure of the constructed construction. With a good understanding of material and a little skill, hempcrete is an excellent material for building of healthy and sustainable buildings in the future.

1 Hemp as a building material

1.1 Cannabis

Hemp is a fast-growing upright one-year-old plant that can grow from 1.5 m to 4 m. It usually has only a few branches at the top of the plant. It has a thin and hollow stem with a diameter of 4 mm to 20 mm, depending on the conditions and the specificity of the growth. The fibres that are contained in the bark of woody stalk are 1.2 m to 2.1 m long and are extremely strong. Their quality varies depending on the harvest time of the plant and the fibres are sorted with regard to their fineness, length, colour, uniformity and strength.

The inner, wooden part of the stem is called shives, and it was not used in the history so much. It is used for packaging as beddings for animals, and also for the production of hempcrete, lime and clay plasters. Hemp seeds are used as a food and basis for the production of oils for various purposes, fuels, resins, including technical and industrial applications. They are further used in cosmetics and in the manufacture of medicaments on a natural basis. The entire plant can be used as a bio fuel and even the hemp cellular fluid is used in the production of abrasive liquids [1].

Furthermore, hemp has been used during religious rites and lately as a recreational drug, publicly known as marijuana, due to its mild psychoactive effect. This eventually led to the fact that cultivation and holding of this plant was banned in most Western countries in the first decades of the twentieth century. This also involved a ban on the cultivation of all varieties of the hemp plant. Since the 1930s, much effort has been put into developing varieties with a very low THC content (tetrahydrocannabiol). The success of this effort has been for several decades available hemp plant with very little or no THC content.

Basic varieties of hemp [2]:

- *Cannabis sativa:* an annual plant, dioecious plant. There are a large number of geographical ecotypes that differ from one another.
- *Cannabis indica*: an annual plant that grows up to a height of 1.5 m. Compared to the cannabis sativa, indica is richly branched and has wide leaves. It is grown for high levels of narcotics (1-8 % THC, marijuana) and for hashish (3-15 % THC) in India, Turkey, Iran, Syria, North America and it grows wild in Pakistan.
- *Cannabis ruderalis*: it differs from the previous two by blooming for a predetermined number of days; it is not dependent on the season and the minimum content of the psychoactive substance THC. It is an economically insignificant one-year weed, adapted to self-seeded. It grows predominantly in steppes.

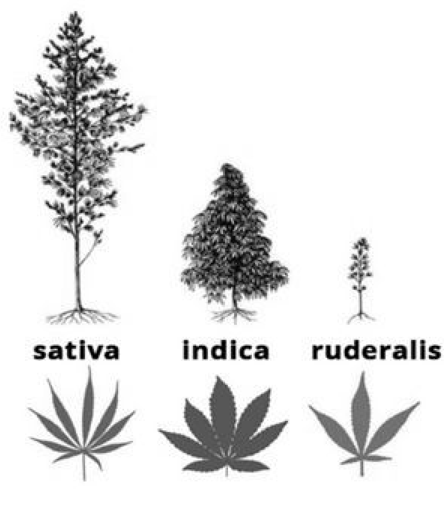


Fig. 1. Varieties of hemp [3]

Cannabis grows in soils and areas with soil pH 6.5 and above (from neutral to alkaline). It is not nutritionally demanding, but it is necessary to fertilize it for maximum commercial yield. The plant penetrates its roots deeply so it helps to break the soil to a certain depth, which is beneficial to soil health and its condition.

Moreover, by exploiting of nutrients it prevents the contamination of groundwater by nitrogen. As the plant grows very quickly, it effectively suppresses weeds. It is resistant to pests and therefore does not require chemical herbicides or pesticides.

Among the disadvantages of the hemp are its collection and processing. Appropriate processing lines and harvesting mechanisms are needed [4].

1.2 Hempcrete

HEMPCRETE is a well-known mark for composite material composed of hemp and lime. It is formed by wet processing, by mixing chopped wooden stems, called shives and lime-based binders. The mixture thus formed is deposited in moulds or formwork to form a non-load-bearing, durable, breathable, vapour permeable and insulating material that can be used to form walls, floorboards, ceilings and roof insulation in new or restored buildings.

The place of birth of hempcrete is France, sometimes in the mid-90` of the 19th century. The reason for this was finding of a suitable substitute for damaged withy and clay in the medieval half-timbered buildings. In Japanese village of Miasa, the prefecture of Nagano, they built a hempcrete house in 1698, which stands to this day and is currently recognized as a Japanese national monument [5]. In Europe, because of the extensive damage caused by the post-war period, the Portland cement was used for the repair of buildings. Replacement of natural, vapour-permeable materials by Portland cement has prevented historic buildings from breathe, resulting in moisture retention in structures and thus causing damage to wood beams.

The replacement was requested not only to be vapour-permeable but also insulating. It has been found that the stem of the hemp is an ideal ingredient that together with lime mortars will achieve this effect. Due to the cellular structure along with the properties of the lime binder, hempcrete has a good ability to absorb and release moisture depending on thermal and humidity conditions, as confirmed by research in laboratories [6, 7]. Thanks to the large amount of air trapped in the hempcrete wall, it achieves good insulation properties.

Hempcrete can be divided according to the method of production [8]:

Concrete produced on the site means mixing the hempcrete components on the construction site and then placing it in the moulds from the formwork. Because hempcrete is not a load-bearing material, it is always stored around the construction frame that forms the main supporting part of the building. Typically, the frame construction is made of wood. The production process is simple with minimal mechanization (a cement mixer and a chain of people to transport buckets with hempcrete). Another advantage is the ability to form a continuous monolithic layer of insulating material in the building structure and the possibility of forming it in almost any shape that requires the design of the building. This allows the hempcrete as insulating material to minimize cold bridges and ensure exceptional air tightness. These two relatively significant characteristics give hempcrete a considerable advantage over the use of contact thermal insulation systems, especially in new buildings [9, 10].

Prefabricated blocks or panels are dried before being brought to the construction site, thereby shortening the construction time compared to hempcrete produced on the site. The disadvantage is a more complicated method of using hempcrete, which involves a larger number of processes and the necessary building materials. This is therefore a less appropriate method in terms of sustainability of construction [2].

1.3 Binder for hempcrete

The most expensive component of hempcrete is a binder. At present, the most commonly used is the industrially produced binder under the Tradical brand. Its composition consists of approximately 75 % white slaked lime, 15 % hydraulic binders and 10 % pozzolans. The lime base ensures a diffusion-open, final material that is breathable and equalizes moisture in buildings. The lime additionally mineralizes wood and therefore also wooden structures that are forming supporting frames. This protects and extends lifetime. Therefore, the effort is to partially replace the time of this binder by suitable impurities. They must not be on a cement base which closes the structure in diffuse way and thus the material would lose all the benefits of hempcrete [11].

One possibility is zeolite. The natural zeolite is also referred to as natural pozzolan (volcanic sedimentary waste rock, according to EN 197-1) [12]. Zeolite as well as other pozzolans in the contact with water does not harden. To produce this reaction, the presence of water mixed with calcium hydroxide $Ca(OH)_2$ (slaked lime) is required to form calcium aluminates and silicate compounds. They cause gradual increase in strength of building materials.

The density of the milled zeolite ranges from 2 200 to 2 440 kg/m^3, with a bulk density of 1 385 to 1 905 kg/m^3. The porosity reaches 24-32 % and the absorbency is about 39 % [13].

2 Experimental study

Shives fractions of 15 mm and Tradical PF 70 binder (manufactured by Lhoist - BCB Balthazard & Cotte Batiment, France) were used to produce the samples. The content of the binder was modified by a dose of zeolite (comp. Zeocem, a.s., deposit Nižný Hrabovec) in various ratios, shown in tab. 1.

The basic recipe was based on the manufacturer's instructions for wall preparation, where, based on the consistency test (friability after a finger press after shaping the balls, the water was increased from 325 kg/m^3 to 350 kg/m^3. This amount was constant as well as the dose of shives for all the mixtures that were produced.

Table 1. The overview of mixing ratios

Mixture	Mixing ratio Tradical PF70:zeolite	Tradical PF70 [kg/m^3]	Zeolite [kg/m^3]	Hemp shives [kg/m^3]	Water [kg/m^3]
Basic recipe		220	-	110	325
0	5:0	220	-	110	350
41	4:1	176	44	110	350
32	3:2	132	88	110	350
11	1:1	110	110	110	350

The production consisted in mixing dry ingredients with shives where subsequently the water was added. The mixture was stirred until it was homogeneously mixed. 100 mm-sized cube samples were produced and stored in the moulds for 7 days. After they were removed from the moulds, the samples were stored under laboratory conditions (temperature about 20 °C and relative humidity φ 50 – 60 %). The thermal conductivity coefficient was measured on these samples, as well as the thermal capacity, the bulk density and the tensile strength on days 7, 28 and 91. At the same time, a decrease in weight was measured that was caused due to drying of the samples with more frequent measurements (1, 2, 3, 7, 14, 28, 56 and 91 days).

The main monitored property of hempcrete was the thermal conductivity coefficient. This is the amount of heat that passes over the unit of time by the body so that the unit of length corresponds to the unit temperature gradient. Determination of thermal conductivity was carried out by a measurement instrument – Isomet 2114 with a square probe, where the resulting value was an average from 4 measurements per sample.

3 Achieved results

The bulk density, the compressive strength, the thermal conductivity coefficient and the volume heat capacity of the hempcrete samples are showed in tab. 2.

The bulk density after unmoulding ranged from 540 to 600 kg/m^3, with the lowest reference samples being reached. Sample drying resulted in a significant decrease in volume weights (by 35 % on average), after 28 days of 340 to 390 kg/m^3, the further course was no significant change and the sample maintained a constant bulk density.

Due to the nature of this material, the compressive strength of the cubes was low. After deformation, the samples were brittle, achieving very low strengths (Figure 2). After drying, despite the drop in bulk density, their strength increased two to three times as a result of hardening of the binder. After 91 days, the samples retained the strength with a slight decrease. The highest strengths were found with the lowest zeolite doses (labelled 41). With a higher zeolite dose, strength characteristic was decreasing; the highest dose of zeolite (11) had lower strengths than reference samples without zeolite (0).

Table 2. The overview of archived results

Age of sample [day]	Mixture	Bulk density [kg/m^3]	Compressive strength [MPa]	Thermal conductivity coefficient [W/m.K]	Volume heat capacity [J/m^3.K]
7	0	540	0.06	0.2740	0.8137
	41	597	0.11	0.2492	0.6221
	32	573	0.07	0.2434	0.6889
	11	557	0.05	0.2465	0.6194
28	0	341	0.17	0.0782	0.2733
	41	387	0.26	0.0879	0.3002
	32	367	0.14	0.0813	0.2923
	11	350	0.09	0.0794	0.2898
91	0	340	0.16	0.0778	0.2019
	41	353	0.24	0.0880	0.3079
	32	357	0.12	0.0831	0.2956
	11	347	0.08	0.0796	0.2805

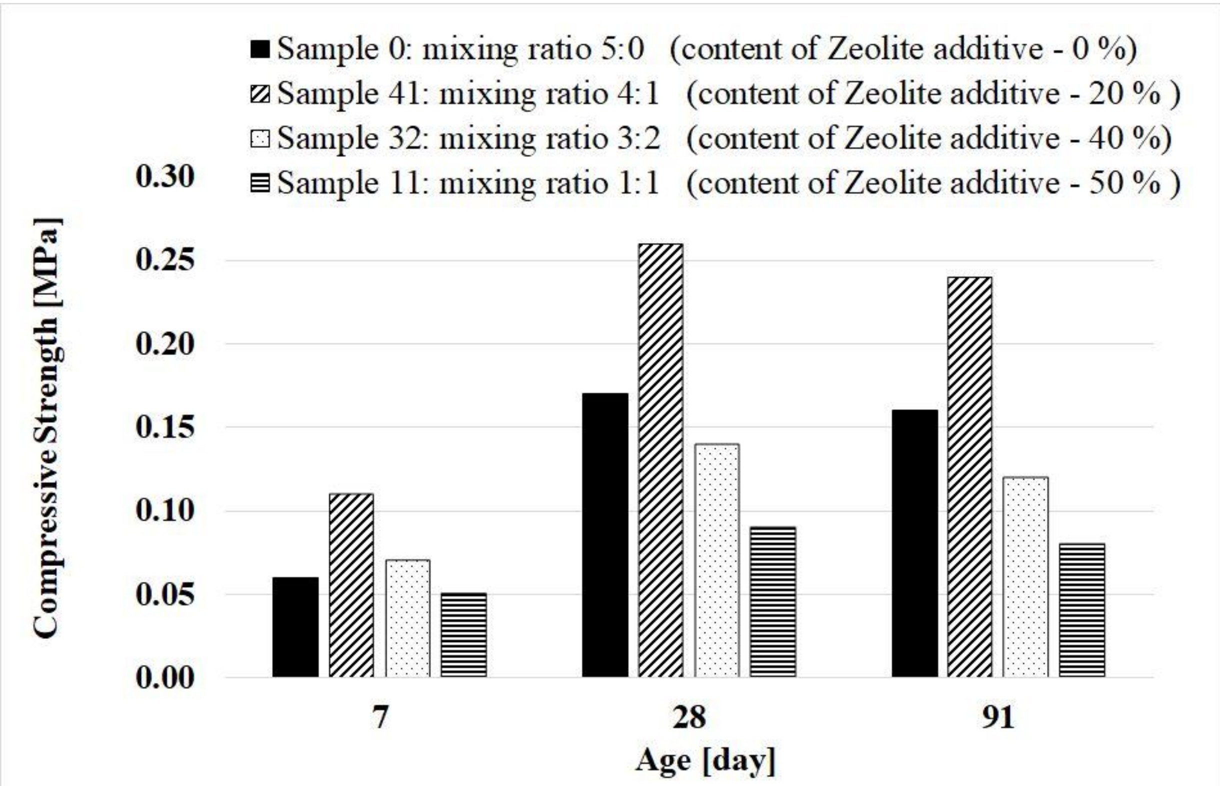


Figure 2. The course of compressive strength on the test cubes

Higher water content after unmoulding is also associated with the thermal conductivity coefficient. While on the first measurements the values ranged from 0.24 to 0.27 W/m.K, they dropped to 0.078 to 0.088 W/m.K after drying. The lowest values were achieved by reference samples as well as samples with the highest dose of zeolite (11). With a decreasing amount of zeolite, the thermal conductivity coefficient slightly increased (Figure 3). Likewise, the values of the volume heat capacity are similar.

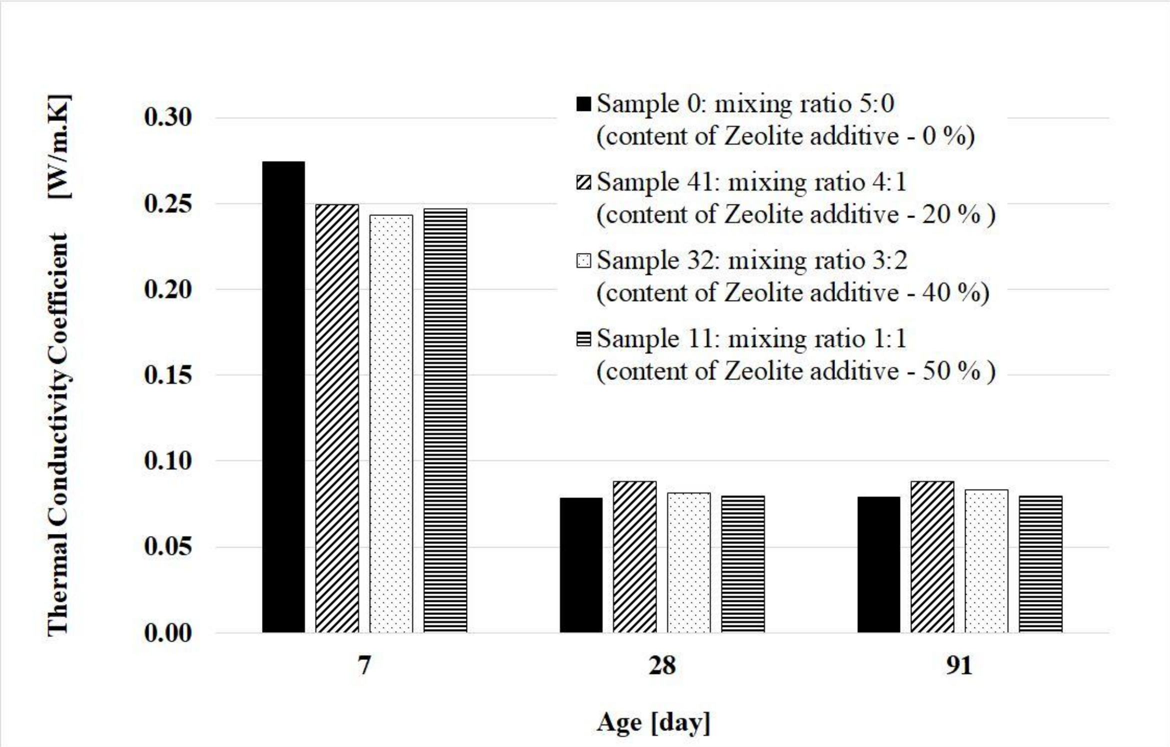


Figure 3. The course of thermal conductivity coefficient on the test cubes

The weight loss procedure confirmed the intensive drying of the samples after deformation, when the weight decreased by 9 to 18 % within 24 hours and an additional 9 % during the next 48 hours. The exception is the mixture with the highest zeolite content (11), where the weight decreased in a longer and slower rate. These results are given in tab. 3 and fig. 4.

Table 3.The weight loss of test samples

Unmolding time [day]	Weight loss of mixture [%]			
	0	41	32	11
1	13.38	9.25	17.73	9.23
2	19.96	17.34	23.00	10.78
3	21.26	18.14	26.94	12.22
7	21.90	18.80	29.32	13.61
14	22.07	19.07	29.53	14.67
28	22.25	19.38	29.77	16.53
56	22.50	20.15	29.89	20.07
91	22.76	20.81	30.02	20.14

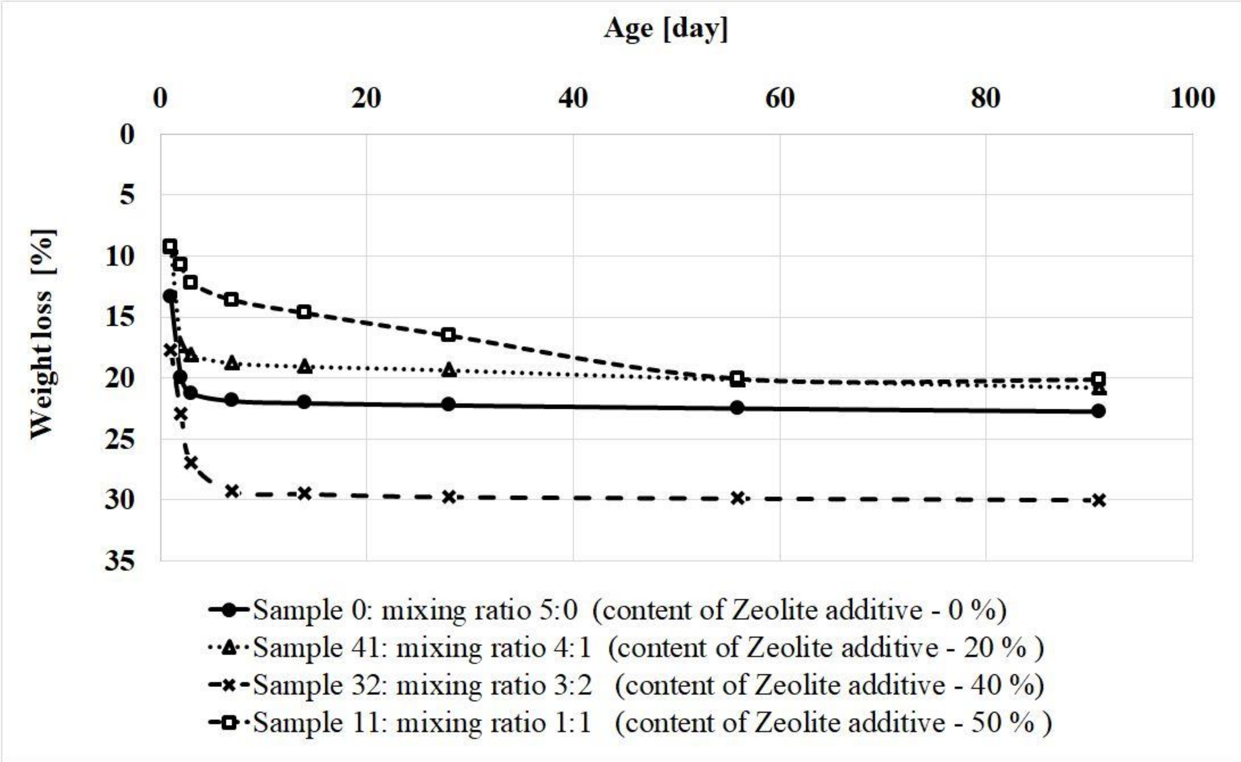


Figure 4. The course of weight loss of the test cubes

4 Conclusions

Based on the obtained results we can conclude that the zeolite mixtures had a positive influence on the compressive strength of the test samples, although but to a certain amount of zeolite only. With the increasing amount of zeolite, the compressive strength decreased and the samples reached lower compressive strengths values than the reference mixtures. The opposite effect to the thermal conductivity coefficient had the zeolite mixture. The higher dose resulted in a decrease of the thermal conductivity coefficient that was comparable to the reference mixture. In the longer term, it would be appropriate to focus research to monitor the properties while using lower doses of zeolite and so find their ideal ratio.

REFERENCES

1. Roulac, J. W. Hemp Horizons: The comeback of the world's most promising plant. White River Junction, Vermont, Chelsea Green Publishing Company; first edition, sept. 1997.
2. Porvaz, P., Tóth, Š. Stričík, M. Význam a pestovanie konopy siatej Cannabis sativa L. pre energetické účely na Slovensku [Importance and Cultivation of Cannabis sativa L. for energy purposes in Slovakia]. Centrum výskumu rastlinnej výroby Piešťany [Research Center for Plant Production Piešťany], 2011, 34 p., ISBN 978-80-89417-36-0. Available at: http://www.vurv.sk/fileadmin/CVRV/novinky/2013/Konope_-_odborna_publikacia.pdf (in Slovak).
3. Šedivý, M. Dům z konopného betónu [Hempcrete House]. Impact HUB Praha, Stavby z přírodních materiálů [Impact HUB Prague, Buildings made of Natural Materials]. 2015, Environment, 69 p., Available at: https://www.slideshare.net/Marekediv/stavba-z-konopnho-betonu (in Czech).
4. Kabašta, R., Hrčková, K., Mihalčík, P. Pestovanie konopy siatej odrody Finola [Cultivation of Finola hemp for Seeds]. Pestovateľské technológie a ich význam pre prax, Zborník vedeckých prác [Growth Technologies and their Importance for Practice, Collection of Scientific Papers], 2014, Piešťany, pp. 55 – 59, ISBN 978-80-89417-55-1. Available at: http://www.vurv.sk/fileadmin/CVRV/subory/Zborniky/Pestovatelske_technologie/Pestovatelske_technologie_2014.pdf (in Slovak).
5. www.hempcretewalls.com/images
6. Števulova, N., Kidalova, L., Junak, J., Cigasova, J., Terpakova, E. Effect of hemp shive sizes on mechanical properties of lightweight fibrous composites, Procedia Engineering, 2012, Vol. 42, pp. 496 - 500.
7. Stevulova N., Kidalova L., Terpakova E., Junak J. Utilization of hemp concrete as building material. In: Ural O, Sahin M, Ural D, editors. Proceedings of the XXXVIII IAHS World Congress "Visions for the Future of Housing – Mega Cities", Istanbul: Istanbul Technical University; 2012, pp. 358-364.
8. Stanwix, W., Sparrow, A. The Hempcrete Book. Designing and building with hemplime. Cambridge, England, Green Books 2014, ISBN: 978-0857841209
9. Antošová, N., Ďubek, M., Petro, M. Verification of the technology choice repairs ETICS. In Advances and Trends in Engineering Sciences and Technologies II: proceedings of the 2nd International Conference on Engineering Sciences and Technologies. High Tatras Mountains, Tatranské Matliare, Slovak Republic, 29 June - 1 July 2016. 1. vyd. London : Taylor & Francis Group, 2017, pp. 323-328. ISBN 978-1-138-03224-8.
10. Antošová, N., Ďubek, M., Petro, M. Diagnostics to determine the cause of occurrence of cracks on ETICS. In Advances and Trends in Engineering Sciences and Technologies II : proceedings of the 2nd International Conference on Engineering Sciences and Technologies. High Tatras Mountains, Tatranské Matliare, Slovak Republic, 29 June - 1 July 2016. 1. vyd. London : Taylor & Francis Group, 2017, pp. 317-322. ISBN 978-1-138-03224-8.
11. www.mabeko.cz/detail/134-konopn-zdivo-vplov-ed/
12. STN EN 197-1 Cement. Časť1: Zloženie, špecifikácie a kritéria na preukazovanie zhody cementov na všeobecné použitie [Cement.Part 1: Composition, specifications and conformity criteria for common cements].
13. http://www.vskpro-zeo.sk/technicke-parametre-zeolitu/

4.2. INFORMATION MODELING IN THE RATIONALIZATION OF THE PARAMETERS OF IRON CONCRETE CONSTRUCTION ANISOTROPIC SHELLS

Haponova Lyudmila, Hrebenchuk Sergii

Principles of the formation of shells effective solutions. The world dualism conditions the direct search for the constructive solution of the mechanic system developing towards the scholarly works by V.S. Shmukler [1]: creation of elements (constructions) with the maximum bearing capacity and/or rigidity at the given material consumption; creation of elements (constructions) with the minimum material consumption at the given resource (fig.1).

Fig. 1. Architectural and compositional complex in the form of Mobius band.

In both cases the problem comes down to the settlement and solution of non-linear rationalization (optimization) problems. As it is known, the complexity level of the applied methods and realization algorithms in this case is much higher than in case of the common (traditional) approach. Besides, the solutions formed are directly connected with the specific conditions of loading and support of the constructive elements which localizes the sphere of their application.

Formulation of the corresponding criteria in the logically grounded and physically justified terms is discussed in the works of scholars [2-9].

Peculiarities of modeling the energy portrait of the construction. Ideology of the direct forward engineering problems settlement presented below provides for (though approximate) manifestation of two conditions:

- introduction of the sole objective function as a criterion;
- restrictions with regard to the condition connected with the stress-strain behavior management.

In this case, as it is known, essential simplification may be achieved in the settlement of problems of constructive elements parameters rationalization. It is expected here that equal record of the objective function reflects the probability of the close equivalent change of traditional criteria (value, weight, volume, etc.) the one connected with the nature and peculiarities of stress strain condition. The same requirement applies also to the restrictions which predetermine the stress strain condition management.

In its turn, the virtual diversity of restrictions describing the region of feasibility, conditioned the construction of procedure composed of two stages [1]:

- searching for the model solution;
- formation of the final solution.

Besides, for the construction of the model solution it was considered rational to use the new provisions based on the energy principles [63], mainly:

- statement that for the regulated systems with the constant material volume, number of external and internal bounds (external parameters) under the influence of static external load – dead weight, strain potential energy (SPE) after the reconstruction achieves the lower limit on the rational combination of the geometric parameters values:

$$U = \inf_{\alpha} U(\alpha^k), k = 1,2,\dots\infty, \tag{1}$$

where U - SPE; k – number of comparison variant; $\alpha \in M$; M – numerous permissible values of the external geometric parameters.

Provision may be widely used (1) in case of presence of dominating element on numerous virtual loads. In particular, when combining the thin-walled element subject to the twist bending strain, the rotation torque can be minimized due to the passing of the loading vector through the bending centre which will correspond to the fulfillment (1). This will result in the refuse from the formation of element with the close loop (fig.2) [1];

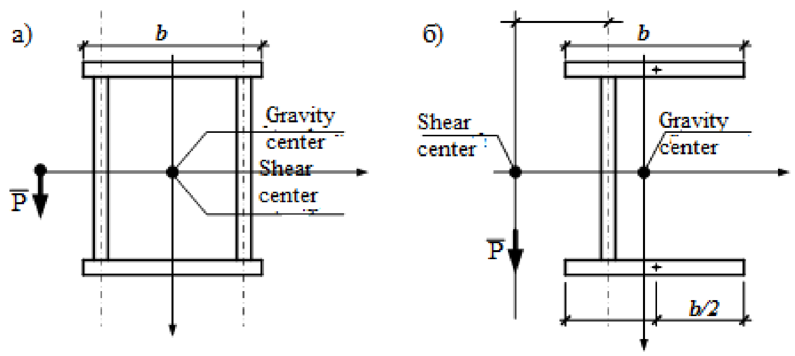


Fig. 2. Crossing of elements subject to the bending with torsion:

a) closed section (traditional solution); b) open section (rational solution).

- requirements of the system (construction) status iso-energeticity, i.e., the one in which: $e[\{\bar{x}\}] = \text{const},$ (2)

where e – is the strain energy density(SED);

{x} – internal parameters vector.

Solution of practical problems with the criterion (1), to certain extent confirms the efficiency of its exploitation, and the possibility of regulation not only with the geometric but also with the physical and mechanical system characteristics [10;11].

Let us assume that [1, 10], the external extensive parameters mean the parameters determining the system resistance without changing the total amount of material (system elements parameters, strong couplings coordinates and places of loading application etc.), internal intensive parameters determine the typology, volume and peculiarities of the materials.

It is also noteworthy that the first provision, apart from capacity (1), is the following:

- in case of avalanche-type decoupling due to the appearance of the plastic centroids, till the appearance of the limit condition, when the system turns into the mechanism, SPE grows and achieves the upper limit:

$U_u = \sup U,$ (3)

where U_u – is the SPE limit value.

Condition (3) may be used when determining the most dangerous combination of loads, in case of the loading diversity. Obviously, the most dangerous loading (in case of the elastic deformation) will correspond to the higher SPE value;

The criterion results in the fact that (2) at $e = e_u$ in all construction points the global minimum of material consumption is achieved (1). Here the fundamental structure-forming value e_u- the resource, essence is the material toughness degree or the deformation energy ultimate density [1, 10]. It is determined by the work used for the sample deformation until its destruction which coincides with the volume unit and the measured area of the material deformation indicator diagram. Resilience which is a very valuable construction quality is connected with the size of the resource, and is determined by the amount of strain energy which may be preserved in it. In its turn, the isoenergeticity which is generated (2) as a rational form of artificial elements existence, provides for the most acceptable material distribution as well as its efficient work in the construction. Applying the iterative approach to (2), based on the adaptive revolution method (ARM), for any geometric or physical and mechanical construction parameter the following may be recorded [10]:

$$h_{i+1} = h_i[e_i e_{\mathrm{iu}}^{-1}]^{\gamma}, \tag{4}$$

where h – is the geometric (physic-mechanic) system parameter;

i – iteration method;

$\gamma \in (0,1)$ - characteristics of the adaptive evolution reflecting the convergence rate.

The presented provisions allow not only determining the model solution, but, which is very important, building the energy portrait of the construction. It means the 3D-construction and reflection of the strain energy density filed with the simultaneous SPE determination. This condition, along with the determination of the system rational topology (not only the form, but also the content) conditions the determination of the limit state both for the structural elements of the construction (for instance, finite elements) and for the system in general. Besides, on condition of the procedure convergence (4), the system unloaded (freeload) elements are dropped out. Noteworthy that apart from the minimization of material consumption the criteria

(1) ÷ (2) may be used for the approximate estimate of some important mechanic characteristics.

3.The procedures of improvement the constructive characteristics of building envelopes. The approach realization provides for the establishment of connections between the value of the system deformation energy and one or a group of geometric parameters. The settlement of such task in the numeric expression is possible in case of application of the computer software systems, however, the transaction provides for the construction of a great number of models which to certain extent complicates the process. The settlement and realization of the task of the suggested iron concrete shells construction parameters rationalization is presented. For this task the energy principles are taken as a criteria according to which out of all variety of possible values of the searched parameters of system with the constant material volume, number of external and internal connections, the SPE after the reconstruction will reach the lower limit, on the rational combination of values of the geometrical parameters describing the system. Realization of approach in this case presupposes establishment of interconnections between the system deformation energy value and one or a group of the geometric parameters.

The paper realizes the numerical methods of solving the settled task as exemplified by the cylindrical envelope with the rectangular internal gaps (fig. 3.).

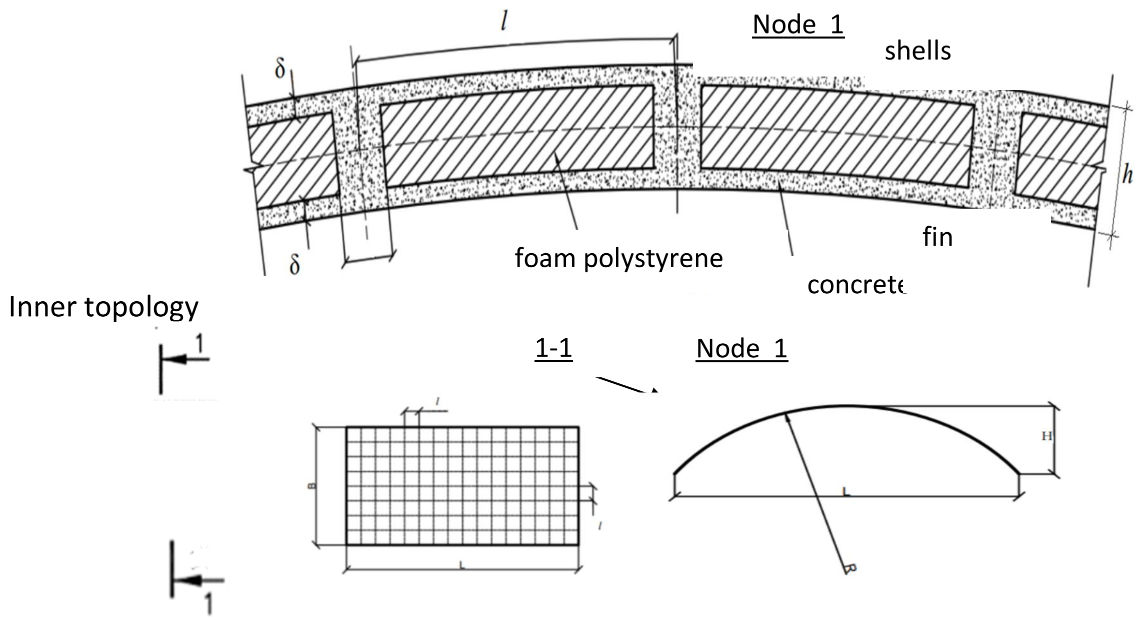


Fig. 3. Considered shell

The consideration includes the vector of the system control parameters:

$$\{x\}^T = \{H, \mathrm{B}, V, R, L, l, q, \delta, \Delta, h\}, \quad (5)$$

Where H – camber of arch; B – length of the shell; V – material volume; R – bend radius; L – shell passage; l – fin pitch; q – external loading; δ – shell thickness; Δ – fin thickness; h – shell contour interval.

In this case the parameters H, B, R, L, q – are considered external and parameters l, δ, Δ, h – are considered internal.

The Autodesk program products bunch was taken as an instrumentarium for solving the settled task.

The script developed in the environment of Dynamo visual programming is basic here and allows for the automatic formation of the shell geometry through specifying all necessary parameters out of {x} value. In general terms the shell stress strain condition determination is presented as an algorithm.

The suggested procedure allows building the interrelations between the system SPE and any geometric parameter describing it. For illustration the samples are considered of searching for the external and internal shell parameters.

During the analysis of external parameters the camber of arch H ∊ (H [0; L / 2]) is taken as a variable, other parameters describing the system geometry are taken as follows: B = 9000 mm; L = 18000 mm; h = 300 mm, Δ = 100 mm; l = 1000 mm. The dead load is taken as a loading, the supporting is taken as hingedly immovable behind two longitudinal stringers, material – concrete C25/30.

Ste-by-step changing the H parameter, its connection is determined with the system SPE value, and in all cases the shell material volume was still the same – its stability was provided for through the selection of the corresponding value of the shell thickness δ.

The calculation results are shown in the table 1.

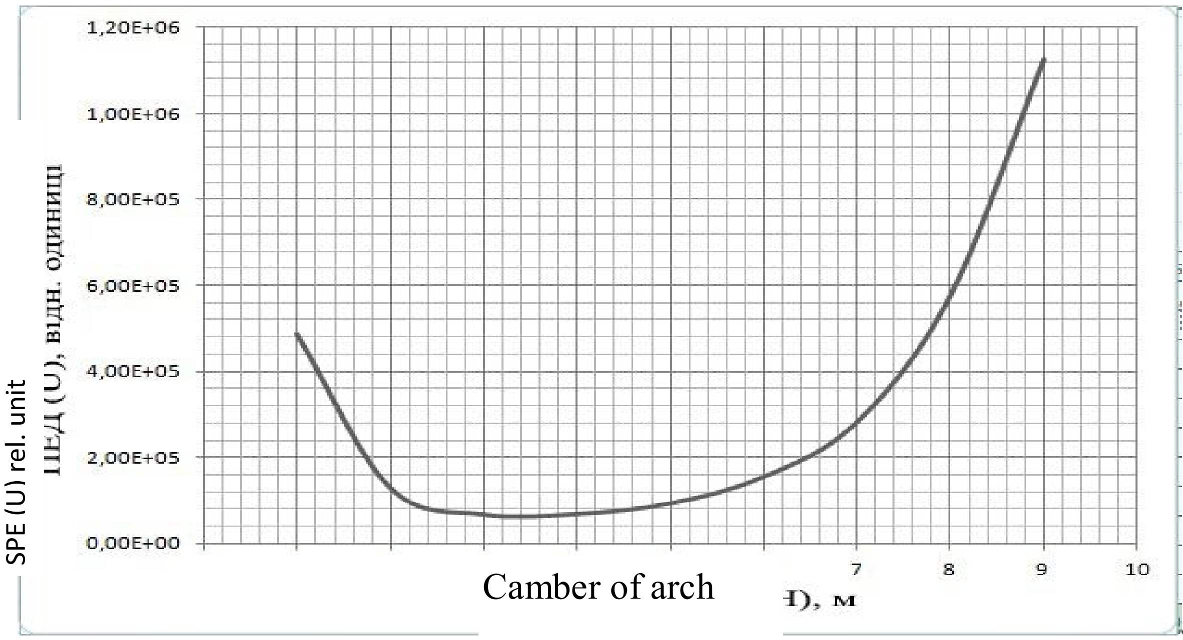
Table 1. Calculation results

Camber of archH	**Material volume V**	**Curve radius R**	**Shell thickness δ**	**Arch length**	**System SPE U**
m	**m^3**	**m**	**mm**	**m**	**Relative un.**
0	22.89	∞	50.60	18.00	5.75E+06
1	22.89	41.00	50.00	18.14	4.87E+05
2	22.89	21.25	47.30	18.58	1.30E+05
3	22.89	15.00	45.0	19.30	7.57E+04
4	22.89	12.12	40.70	20.28	6.93E+04
5	22.89	10.60	35.70	21.50	9.38E+04
6	22.89	9.75	31.50	22.93	1.55E+05
7	22.89	9.28	27.10	24.55	2.83E+05
8	22.89	9.06	22.40	26.34	5.77E+05
9	22.89	9.00	18.70	28.27	1.12E+06

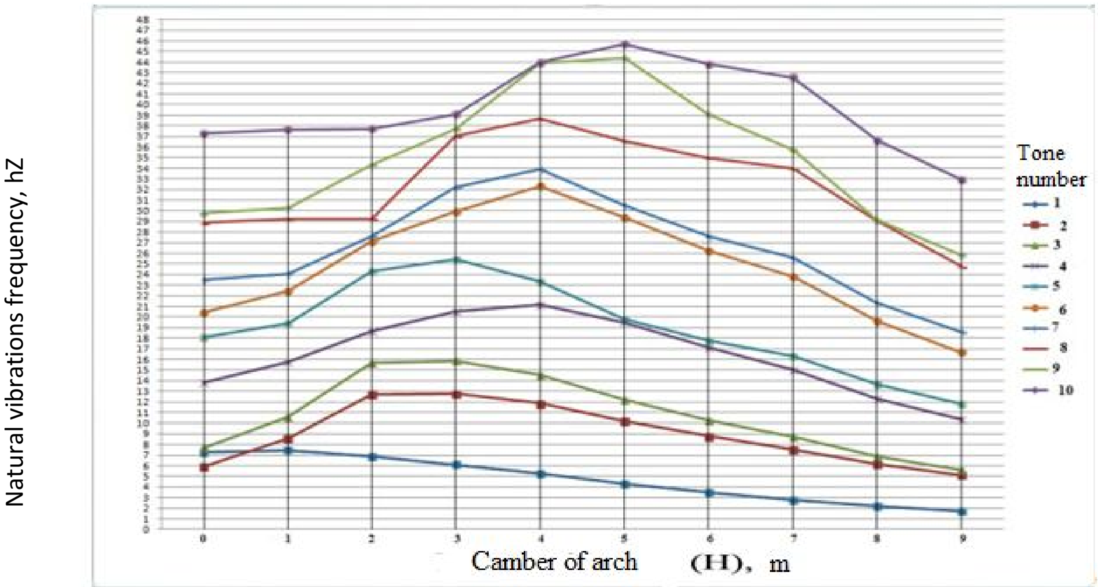
Based on the results obtained, the diagram was constructed of the dependency of SPE upon the camber of arch H (fig.4., a), which is the uni-modal function. It was determined that for the specified conditions with H ≈ 3.8 m SPE achieves the lower limit. The results obtained are verified through the analysis of the system natural vibration frequencies for all H values and assessment of the maximum bearing capacity (q_{max}) of the shell.

Out of the diagrams (fig. 4. b), and from the fig. 3.5-3.16 it can be seen that 7 out of 10 vibration tones acquire the maximum value at H close to rational. Out of the condition of achievement the system equivalent strains (σ_e) of the material resistance limit q_{max} is determined for the H optimal value and values 1m less and more from the rational (4.8 and 2.8 m correspondingly).

Thus, at H = 3.8m q_{max} = 38.45 kN/m^2; at H = 4.8 m q_{max}= 35.15 kN/m^2;at H = 2,8 m q_{max}= 30.26 kN/m^2.



a)



b)

Fig. 4. Connection of the camber of arch H and: a) SPE; b) natural vibrations frequency

For further analysis the shell internal fins *l* (fig. 5.) torque were taken as variables. The other attributes of the calculated model are specified similarly to the above, except for the shell thickness δ, which in this case is taken as 50 mm, and camber of arch H, taken as 3.8 m. The material volume stability, in this case, is provided through the selection of the corresponding fins thickness value Δ. The calculation results are shown in the table 3.2, and on the diagram (fig. 6).

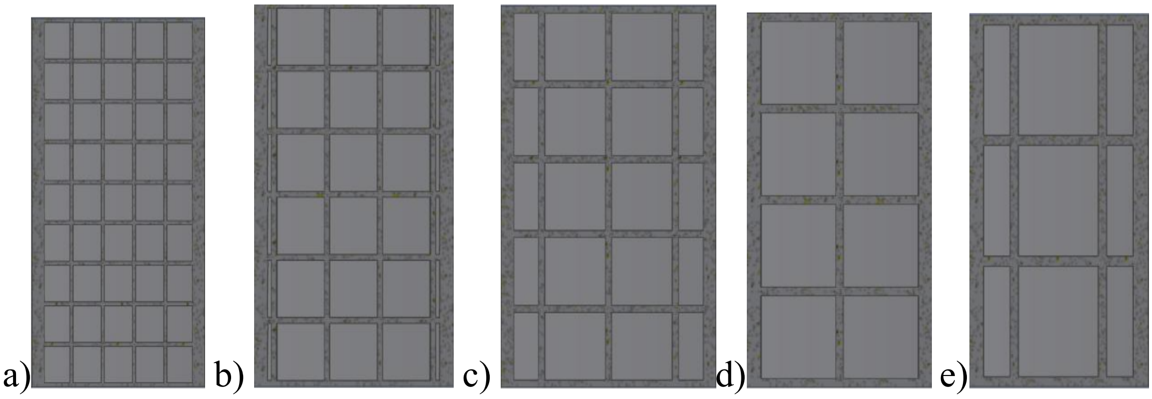


Fig. 5. Fins grid variation. Fins torque. a) 1000 mm; b) 1500 mm; c) 2000 mm; d) 2500 mm; e) 3000 mm.

Table 2.Calculation results

Fins torque, ***l***	**Fins thickness,** **Δ**	**Material volume,** **V**	**System SPE,** **U**
mm	**mm**	**m^3**	**rel. un.**
500	50	23,509	1,25125
1000	96.5	23,509	1,250747
1500	137.7	23,509	1,253351
2000	166.9	23,509	1,260031
2500	207.3	23,509	1,267818
3000	241.1	23,509	1,297566

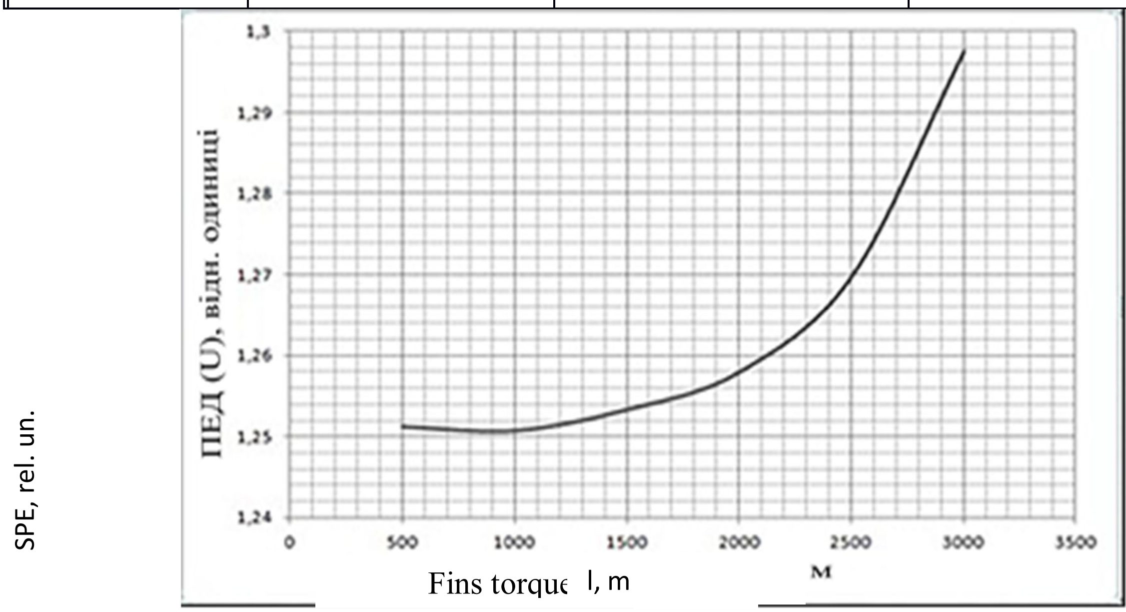


Fig. 6. The diagram of dependence of deformation U energy upon the fins torque

As it may be seen from the graph, in case the fins torque value approaches l ≈ 1000 mm SPE achieves the lower limit. Thus, the suggested approach provides the possibility of determining the rational parameters of iron concrete elements with the complex external and internal geometry.

The provided analysis is expanded due to the studying the distribution of the strain-energy density (inside parameter). In this case, the criterion will be represented by the linear connection

$$e \rightarrow const, \tag{6}$$

where e - strain energy dencity (SED).

SPE Field leveling (Lira Software Complex) is realized due to granting the complex form to the insert-core drives. In this case the fins grid is not orthogonal.

The work employs different researches of two-bended anisotropic shells with the fins in different directions. The interrelation is determined of the rational parameters in the constructive anisotropic shell between the SPE of the system of external and internal rational parameters: with the fins torque value of about l ≈ 1000 mm SPE reaches the lower limit. The obtained results of the external parameters are verified using the analysis of the system natural vibration frequencies for all values of the camber of arch H and maximum bearing capacity (q_{max}) of the shell. It is determined that under the specified conditions with the camber of arch H ≈ 3.8 m SPE achieves the lower limit.

Conclusions: 1. The Paper demonstrates the principles of the design processes optimization based on the interrelation between the numerical and graphical software complexes. The energy criterion is employed as to the rationalization of the external constructive parameters of iron concrete constructive anisotropic shells.

2. According to the research results, it was determined that (for the considered specific conditions) at H ≈ 3.8 m the potential deformation energy achieves the lower limit. The obtained results are verified through the analysis of the system natural vibrations frequencies for all H values and assessment of the maximum bearing capacity (q_{max}) of the shell.

3. The interconnection is determined between the rational parameters in the constructive anisotropic shell between the SPE of the system of external and internal rational parameters: at the fin torque value of about $l \approx 1000$ mm SPE achieves the lower limit.

REFERENCES

1. Shmukler V. S. Karkasnyye sistemy oblegchennogo tipa (Frame-type systems of the light type) // VS. Shmukler, Yu.A. Klimov, N.P. Beet. Kharkiv: Golden Pages, 2008, 336 pp.
2. Abovsky N.P., Andreev N.P., Deruga A.P. Variatsionnyye printsipy teorii uprugosti i teorii obolochek (Variational Principles of the Theory of Elasticity and Shell Theory) / Under the Rev. A. Abovskogo NP: Nauka, 1978.-228 p.
3. Gorodetsky AS, Gordon LA, Gottlide A.A. Staticheskiy raschet betonnykh i zhelezob1etonakh konstruktsiy gidrotekhnicheskikh sooruzheniy (Static calculation of concrete and reinforced concrete structures of hydraulic engineering structures). - M .: Energoizdat, 1982.-240s.
4. Perelmutter AV. Pravleniye povedeniyem nesushchikh konstruktsiy (Control of the behavior of bearing structures). – 2011. – 184p.
5. Goldveiser A. L. Teoriya uprugikh tonkikh obolochek (The theory of elastic thin shells). - 1976 - 512 pp.
6. Tymoshenko SP. Plastiny i obolochki (Plates and shells). - Moscow: YUGIZ, 1948. - 460 pp.
7. Chen W. T. A Hyperboloidal Notch in a Transversely Isotropic Material under a Clean Shear // Journal of Elasticity. - 1972. - T. 2. - No. 2. - P. 113-122.
8. Reissner E., Reissner E. On a Variational Theorem in Elasticity. J. Math, and Phys., 1950, p. 29, No. 2.
9. Shanley F. Weight Strength Analysis of Aircraft Structures. N.York, M-c jrow-Hill, 1952.
10. Shmukler V.S. Novyye energeticheskiye printsipy ratsionalizatsii konstruktsiy (New Energy Principles for the Rationalization of Structures) / V.S. Shmukler // Collection of scientific works of the Ukrainian State University of Railway Transport. - 2017 - Voip. 167. - P. 54-69.
11. Oleg Kalmykov. Use of information technologies for energetic portrait construction of cylindrical reinforced concrete shells / Oleg Kalmykov, Ludmila Gaponova, Petr Reznik and Sergey Grebenchuk // 6th International Scientific Conference "Reliability and Durability of Railway Transport Engineering Structures and Buildings MATEC Web Conf. Volume 116, 2017 "(Transbud-2017) on 10 July 2017.
12. Gaponova L.V. Stress and strain behavior of reinforced concrete anisotropic shell / L.V. Gaponova, S.S. Grebenchuk // Academic Journal. Series: Industrial machine building, Civil Engineering / Poltava National Technical University Yuri Kondratyuk - 1 (48) `2017. - C.108-120.

4.3. INVESTIGATION OF THE STRUCTURAL STATE AND MECHANICAL PROPERTIES OF THE BLADE UNIT OF THE ROTOR OF LOW PRESSURE STEAM TURBINE WITH HIGH FREQUENCY CURRENTS

Glushkova Diana, Voronkov Oleksander, Nikitchenko Igor

In the complex of issues that determine the reliability and economics of the operation turbines operation, thermal and nuclear power plants, the reliability of the blade device - the most expensive and often damaged element of turbines - is of great importance. The conditions of their operation require an increased hardness of the input edges and high erosion resistance, the absence of a negative effect of the formation parameters of the protective coating on mechanical properties, high corrosion properties [1].

This problem is especially acute for the blades of the last stages of low-pressure cylinders, the erosive wear of which largely determines the resource of their work.

One of the ways to reduce erosion wear of working blades is to increase the effectiveness of anti-erosion properties due to reinforcement of the input edges. In the given work results of researches of a condition of a superficial layer of a working blade of a steam turbine from steel 15Х11МФ, strengthened by currents of high frequency for increase of erosion firmness and increase in a resource of work are resulted.

The problem of erosion-corrosion damage of working blades experiencing the operation of a complex spectrum of low-cycle and high-frequency thermo mechanical loads during operation is relevant for more than 70 years [2-5], but up to now it has been partially solved, therefore, studies in the field of hardening of blade material are still important aspect in the solution of this task. Surface hardening with heating of high frequency currents is one of the most common and effective ways of hardening parts.

A feature of induction heating of metals is the generation of thermal energy directly in the product. This introduces certain corrections in the kinetics of the rise in the temperature of the surface and in the temperature distribution across the cross section of the article [6].

In most cases, the greatest operating stresses in machine parts appear in the surface layers. As you move away from the surface, the stresses gradually decrease and disappear in the central part of the product. When the product is loaded with an alternating load, the destruction from fatigue begins in the surface layer.

The greatest surface strength at a sufficiently thick core and a smooth transition between them creates the most rational combination of properties. The degree of smoothness of the transition from the strengthened surface layer to the unstressed core has a great influence on the operational properties of the products [7].

The authors of the work set themselves the task of investigating the state of the surface layer of a working blade of a steam turbine made of 15X11MΦ steel reinforced with high-frequency currents.

Samples for the study were made of steel 15X11MΦ, used to produce stamped blades of the 5th stage of the low-pressure rotor. They were subjected to heat treatment in accordance with OCT 108.020.03 at CP70. The mechanical properties of the material of the initial samples are given in Table 1.

Table 1. Mechanical properties of the investigated blades

Properties	$\sigma_{0,2}$, MPa	$\sigma_в$, MPa	δ_5, %	Ψ, %	KCU, J/cm^2	HB, MPa
Test results	669-750	827-900	15-20	54-58	74-116	248-271
Requirements OCT 108.020.03-82	666,4-813,4	≥814		≥40	≥39,2	248-285

Surface hardening of the input edges of the blades of the 5th stage was performed on the VCHI-63 / 044-3P-LO1 installation with the following technological parameters:

a) operating frequency of the current – 440 kHz;

b) the anode current of the generator lamps is 2.5–3.5 A;

c) grid current of generator lamps – 0,5–1,5 A;

d) the anode voltage of the generator tubes is 3.0–5.0 kV;

This mode provides a quenching temperature of 1050–1150 °C. Cooling of the blades was carried out with water using a sprinkler device. In surface quenching, we sought to obtain a layer of a certain depth with a structure of unstructured martensite. For this, the temperature of full austenization of the steel must be reached at the required depth. In addition, they avoided the through-hardenability of the part. On the working blades after quenching the high frequency currents it is necessary to obtain the depth of the layer on the edge 1 ... 3 mm, on the surface of the outer profile 0.5 ... 1 mm. This depth of the layer provides an increase in erosion resistance in comparison with the blade, heat-treated according to the following procedure: quenching from 1050 °C, tempering 680 °C.

To relieve stress, the blades, hardened high frequency currents, were tempered at 330 °C. Cooling after the release was carried out in the air.

The quality of the surface quenching of the high frequency currents edges of the lo-patches was evaluated: by measuring the micro hardness in the depth of the quenched layer, by studying the structural state, by estimating the distribution of the residual stresses.

The research was carried out on 6 samples cut in different sections of the blade in the transverse direction.

The depth of the quenched layer of samples, measured from the etching background on transverse sections of standard-cut samples, is given in Table 2.

The structure of the surface layer of the blade, hardened by hardening, has a smooth transition from the surface to the core.

The structure of the surface layer of the blade, hardened by hardening, has a smooth transition from the surface to the core.

According to the data given in the table, the depth of the quenched layer of samples differs significantly, which is due to the complicated configuration of the blade profile and, as a result, a different gap between the body of the blade and the inductor, as a result of which the heat input along the blade section is also not stable.

In the section of the external profile of samples No. 5, 6, there is no layer. These samples were cut from the blade near the shroud hole.

Table 2. The depth of the quenched layer of the samples studied

Sample number	Depth of layer, mm	
	external profile	edge
1	0,8	3,0
2	0,9	2,6
3	0,7	0,9
4	0,6	0,6
5	0,0	1,5
6	0,0	1,5

The formation of the structure, as well as the distribution of microhardness, depends on several factors, the main of which are: temperature distribution in the surface zone to the end of heating, the initial structure, hardening of the steel, cooling conditions.

The microstructure of the blade metal after bulk heat treatment is sorbitol with a martensite orientation. The neediness of martensite corresponds to 9–10 points of ГОСТ 8233-56. This martensite is low-carbon and is characterized as coarse-grained.

After surface quenching of HD from the optimal temperatures, the microstructure of the quenched layer consists of structure martensite, which provides a significant increase in strength, ductility and viscosity of the layer. As the distance from the surface increases, the structure grows up to the state of the base metal of the blade.

Measurements of the micro hardness along the depth of the quenched layer were performed on samples cut from the blades of the 5th degree of the low-pressure rotor. They were carried out on a PMT-3 device at a load of 50 g.

The micro hardness distribution over the depth of the quenched layer is presented in the form of graphs in Figures 1-2. The selected regime of surface quenching with heating of the high frequency currents provided: the depth of the quenched layer was 0.6–3.0 mm. The conditional boundary of the depth of the hardened layer, determined by measuring the micro hardness, is 3300–3500 MPa, which corresponds to the depth of the hardened layer, determined after etching, by 90–100 %.

The results of high frequency currents steel tests from edge to center are shown in Table 3.

The results of nano identification correlate with the values of micro hardness.

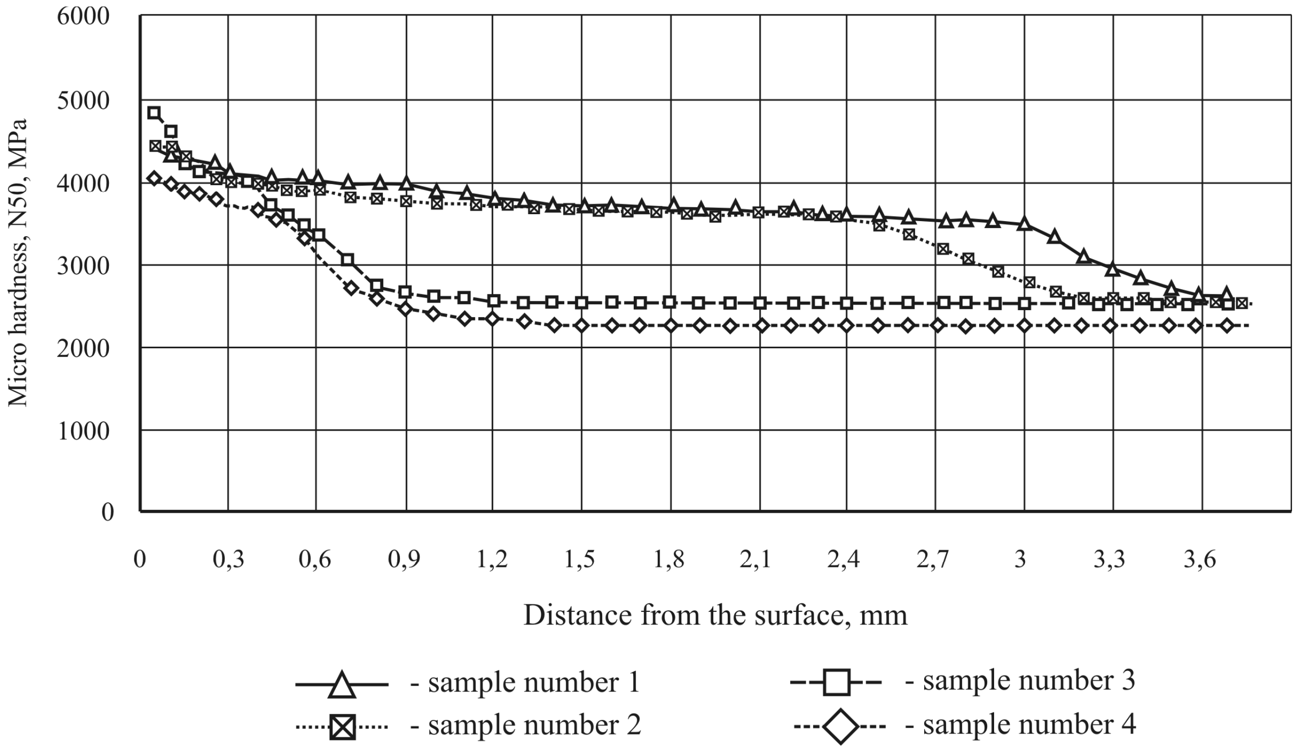


Fig. 1. Distribution of micro hardness from the surface to the core along the outer profile of the blade

The selected regime of surface quenching with heating of the high frequency currents ensured: the depth of the quenched layer was 0.6–3.0 mm. The conditional boundary of the depth of the hardened layer, determined by measuring the micro hardness, is 3300–3500 MPa, which corresponds to the depth of the hardened layer, determined after etching, by 90–100%.

Samples on which the depth of the layer is maximal have a smoother drop in micro hardness over the depth of the quenched layer compared to samples having a minimum depth of 0.6 mm. In the surface zone of the samples, the micro hardness has a maximum value at the level of 5600 MPa.

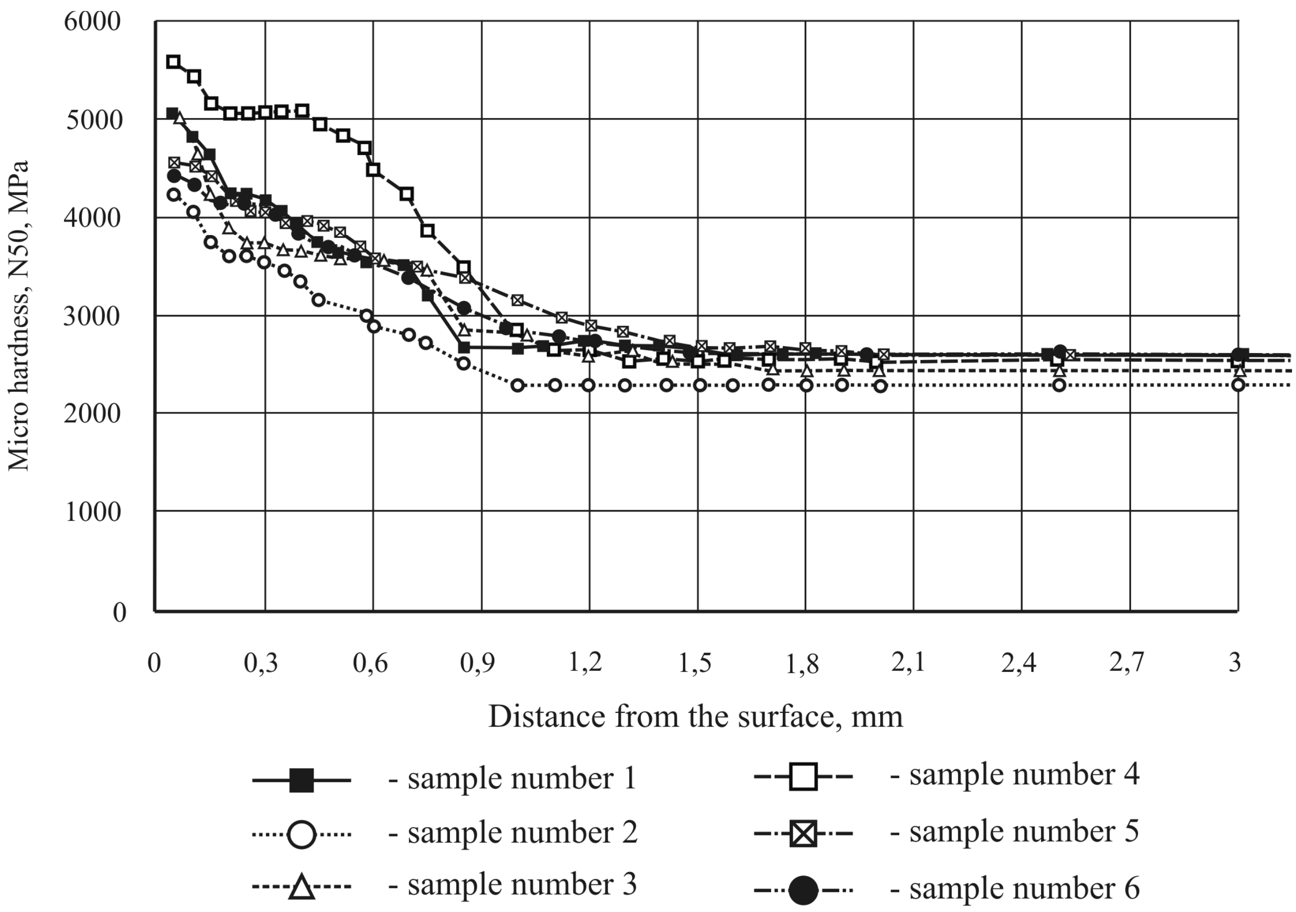


Fig. 2. Distribution of micro hardness from the surface to the core along the edge of the blade

The main nano mechanical properties of the steel sample after HD treatment were tested. nano indentation was carried out by Berkovich's triangular indenter on a Nano Indenter G200 nano scale device, manufactured by the Nano Instrument Innovation Center, Oak Ridge, TN, USA.

The tests were carried out according to the depth of the section from the outer boundary of the sample to the center. The area of the zone was studied after HD treatment. At least 20 prints were applied at a distance of 50 µm from each other. The first point was applied to 50 µm from the edge of the sample. The load on the indenter was 30 mN, the depth of indentation was then of the order of 500 nm. To find the hardness and modulus of elasticity, the Oliver and Farr methods were used.

Table 3. Results of nano indentation

	Distance from the blade surface, μm	Hardness, MPa	Young's modulus, G, Pa
1	50		
2	100	5693	231,556
3	150	5693	231,556
4	200	5946	228,136
5	250	5909	224,831
6	300	5729	243,915
7	350	5804	230,117
8	400	5724	231,218
9	450	5747	236,222
10	500	3512	190,494
11	550	5588	248,881
12	600	5,511	243,706
13	650	5,66	243,437
14	700	3,783	238,907
15	750	4,225	225,022
16	800	4,476	251,423
17	850	4,166	226,672
18	900	3,657	248,519
19	950	3,635	242,899
20	1000	3,706	226,622
21	1500	3,585	238,87
22	2000	3,812	229,934

When hardening with high-frequency currents, it is necessary to obtain compressive stresses on the blade surface, since the tensile residual stresses negatively affect the fatigue strength.

When heated, the surface layer of the blade expands toward the free surface, undergoing plastic deformation. In the first cooling period after quenching tensile stresses appear in the surface layer and plastic deformation of the hot metal occurs. At the same time internal stresses are partially removed. Upon further cooling, the plastic deformation stops and this layer expands, causing considerable compressive stresses in the core. At some point, the outer surface of the heated layer ceases to contract and deforms (shrinks) only under the influence of the inner part of the heated layer. Stretching stresses on the surface are reduced, and their maximum moves to the depth of the metal.

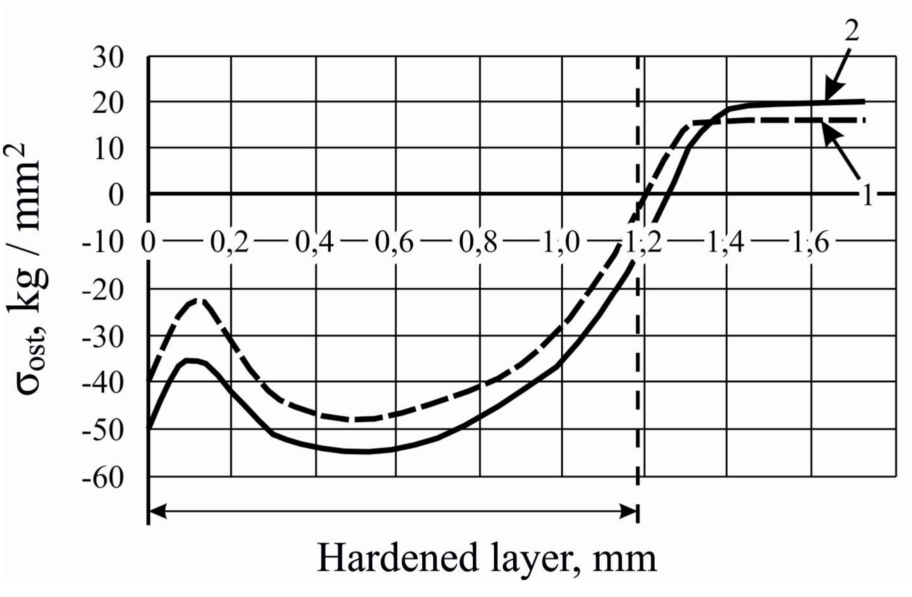
At a sufficiently large depth of the heated layer (more than 3 mm) residual stresses on the surface of the hardened layer completely pass into compressive. The magnitude of the thermal compressive stresses is greater the deeper the heated HDC layer.

The main causes of the occurrence of tensile residual stresses in the vicinity of a solid layer are thermal volumetric plastic deformations during heating and cooling.

Investigations were carried out on the effect of surface hardening of high frequency currents and subsequent tempering on the level and nature of the propagation of residual stresses on the input edge of working blades of the 5th degree of the low-pressure rotor of a steam turbine. The results of the measurements, performed by X-ray tonometry, are shown in Fig. 3.

As can be seen from Fig. 3, compressive residual stresses (up to 55 kg / mm^2) act directly in the hardened layer throughout its depth. At the boundary of the hardened layer with non-hardened metal, the residual compressive stresses grow into tensile (up to 14–20 kg / mm^2), which, however, are not of a peak nature, but spread evenly into the blade.

Thus, the spread of residual stresses, both over the surface of the blade and at its depth, after tempering with heating of the high frequency currents as a whole is favorable.



1 - at a distance of 4 mm from the extreme point of the outer profile

2 - at a distance of 8 mm from the extreme point of the outer profile

Fig. 3. Distribution of residual stresses over the depth of the blade

REFERENCES

1. Subbotin V.G., Levchenko E.V. Povyishenie effektivnosti turbinnyih ustanovok teplovyih elektrostantsiy. [Increasing the efficiency of turbine units of thermal power plants]. Moskva: «Teploenergetika», 2009, pp. 256-350. (in Russian).
2. Smyislova M.K. Issledovanie i razrabotka kombinirovannyih ionno-plazmennyih tehnologiy, obespechi-vayuschih povyishenie ekspluatatsionnyih svoystv lopatok gazovyih i parovyih turbin [Research and development of combined ion-plasma technologies that provide for improved performance of gas and steam turbine blades] // Vestnik UGATU. 2004, 3(11), pp. 45-51. (in Russian).
3. Belyakov A.V. Praktika formirovaniya elektroiskrovyih pokryitiy dlya uprochneniya i vosstanovleniya lopa-tochnogo apparata protochnoy chasti parovyih turbin teplovyih i atomnyih elektrostantsiy [Practice of formation of electrospark coatings for hardening and recovery of the bladed apparatus of the flowing part of steam turbines of thermal and nuclear power plants]. // Vestnik IGEU. 2008, # 6, pp. 24-32. (in Russian).
4. Shvetsov V.L. Kombinirovannaya protivoerozionnaya zaschita rabochih lopatok poslednih stupeney moschnyih parovyih turbin [Combined anti-erosion protection of blades of the last stages of powerful steam turbines] // Vestnik NTU HPI. 2014, 13(1056), pp. 25-32. (in Russian).
5. Fadeev I.P. Eroziya vlazhnoparovyih turbin [Erosion of wet steam turbines]. Leningrad: «Mashinostroenie», 1974, pp. 235-301. (in Russian).
6. Golovin G.F., Zimin N.F. Tehnologiya termicheskoy obrabotki metallov s primeneniem induktsionnogo nagreva [Technology of heat treatment of metals using induction heating]. Leningrad: «Mashinostroenie», 1990, pp. 27-35. (in Russian).
7. Lahtin Yu.M., Leonteva V.P. Materialovedenie [Materials Engineering]. Moskva: «Mashinostroenie», 1990, pp. 265-280. (in Russian).

CHAPTER V
DIGITAL IN ENGINEERING & CONSTRUCTION

5.1. MATERIALS FOR 3D CONSTRUCTION PRINTING

**Savytskyi Mykola, Konoplanik Olexandr, Unchik Stanislav,
Dukat Stanislav, Savytskyi Andriy**

Todey technologies that use 3D printing (Construction 3D Printing (c3Dp) or 3D Construction Printing (3DCP)) are very promising for fabricate buildings or construction components. There are a variety of 3D printing materials used at construction scale: extrusion (concrete/cement, wax, foam, polymers), powder bonding (polymer bond, reactive bond, sintering) and additive welding [1]. In 2013 the Winsun company (Shanghai, China) printed the first batch of 10 houses using a special ink made of cement, sand and fibre, together with a proprietary additive [2]. In research [3] printing mixtures contained Nano-clay, silica fume and fiber inclusion. Authors [4] used cement-based mortar with polypropylene fibre (Table 1). In [5, 6] investigated the influence of superplasticizer on the flowability, buildability and strength of cement-based mortar. Accelerator and retarder were also added to control the reology of mortar.

Table 1 Materials compositions (kg/m^3) for 3DCP

Mix Design	Sand	Cement	Fly ash	Silica fume	Water	Authors
1	1241	579	165	83	232	[4]
2	810	253	192	61	152	[5]

For the technological process 3d print special properties of the mortar are important: extrudabiliti, flowability, buildability, open time, layer adhesiveness [5].
To this technology 3DCP it is important “open time” - the period where the properties of mortar are consistent within acceptable tolerances. Since the setting time of the mortar from which the construction will be arranged is determined by the time of setting the binding substance, it is rational to choose the optimal composition of its components.

The aim of the work was to determine the reactivity of the binder components that make up the composition and to determine their optimum amount in the mixture.

In addition, the task was to compare the timing of the beginning and the end of setting the mortars with various binder components and accelerators.

In research 24 mixtures were prepared and tested. Four different types of binders were used: a) aluminous cement; high-alumina cement; c) portland cement; d) liquid glass; e) powder lime.

The curing agents for liquid glass were: a) sodium silicofluoride; b) ferrochrome slag; c) portland cement M400; d) aluminous cement.

As accelerators for hardening mixtures used: a) building gypsum; b) Calcium chloride $CaCl_2$; c) boric acid; d) soda Na_2CO_3.

To determine the degree of influence of the hardeners, a filler - distensillimanite concentrate was additionally introduced into the composition of the mixture on a liquid glass.

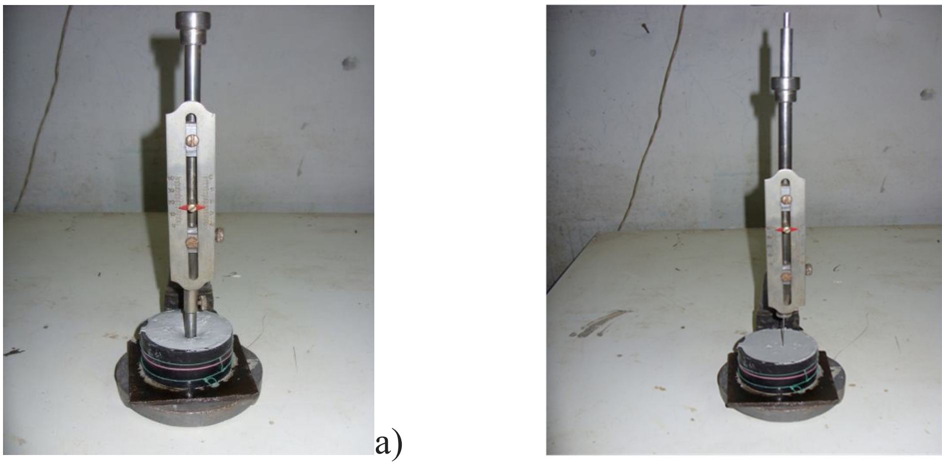
Compositions on cement binders were made by adding a suitable amount of water to the binder. In the case of using the accelerator of the mixture, this solvent was dissolved in water.

The compositions of the liquid-glass mixtures were made in the following order: first, the free-flowing components were thoroughly mixed for 2 minutes, then liquid glass was added and the whole mixture was mixed for 2-3 minutes until a uniform mass was obtained.

Vicat apparatus utilized for determination of consistence and setting time of the mixtures (see Fig. 1). Mortar consistence has a specified resistance to penetration by a standard plunger. For Setting Time Test Vicat apparatus is used too, but the plunger is replaced by the steel needle.

The standard consistence of the mortar was achieved when the plunger was immersed in a ring filled with the mixture did not reach 5-7 mm before the plate on which the ring was mounted.

The setting times were determined by immersing the needle in a concrete mixture. Initial setting time is time measured from zero at which distance between the needle and the base-plate is 4 ± 1 mm. Final setting time is time measured from zero at which the needle first penetrates only 0,5 mm into the specimen.



a) b)

Fig. 1. Testing the standard consistence a) and setting time b) of concrete

Components of mixtures and the results of their tests are given in Table 2 - Table 4.

Table 2 Materials compositions (kg/m3) and mortar properties Mix Design 1-8

Components and properties of mortar	Mix Design							
	1	2	3	4	5	6	7	8
alumina cement	78,4	-	71,9	-	-	-	-	-
high-alumina cement	-	76,9	-	-	-	-	-	-
liquid glass	-	-	28,1	-	-	5,9	11,9	18,9
portland cement M400	-	-	-	78,4	-	73,9	68,6	62,4
portland cement M500	-	-	-	-	77,9	-	-	-
water	21,6	23,1	-	21,6	22,1	20,2	19,5	18,7
Standard consistence	0,275	0,3	0,39[1]	0,275	0,283	0,353[2]	0,457[2]	0,603[2]
Initial setting time, min	380	465	75	190	235	60	17	10
Final setting time, min	590	535	85	255	320	115	110	20

Note: [1] The liquid glass to cement ratio;

[2] The of liquid glass and water to cement ratio.

Table 3 Materials compositions (kg/m3) and mortar properties Mix Design 9-16

Components and properties of mortar	Mix Design							
	9	10	11	12	13	14	15	16
portland cement M400	75,2	69,6	75,8	72,8	73,2	70,3	71,8	72,8
powder lime	-	-	-	-	-	4,2	2,15	1,5
building gypsum	2,2	6,0	-	-	-	-	-	-

calcium chloride $CaCl_2$	-	-	1,5	2,9	-	2,1	2,15	1,5
boric acid	-	-	-	-	2,4	-	-	-
water	22,6	24,4	22,7	24,3	24,4	23,4	23,9	24,2
Standard consistence	0,29	0,322	0,294	0,32	0,323	0,306	0,314	0,32
Initial setting time, min	105	80	80	37	250	35	40	60
Final setting time, min	160	135	135	65	575	70	75	90

As can be seen from the data given in Table 1, the use of cement binders (Mix Design 1-5) in the mortar is characterized by long setting times. At the same time, the beginning of setting is 75-465 min, which means that these binders are not technologically effective when layering the mortar with a 3D printer. The general view of the specimens of compositions 1-3 after determining the setting time is shown in Fig. 2.

Fig 2. The general view of the specimens of compositions 1-3 after determining the setting time

Table 4 Materials compositions (kg/m3) and mortar properties Mix Design 17-24

Components and properties of mortar	Mix Design							
	17	18	19	20	21	22	23	24
portland cement M400	73,3	74,5	74,7	72,0	-	-	3,2	-
powder lime	-	-	-	1,6	-	-	-	-
soda Na_2CO_3	2,2	0,7	0,4	0,4	-	-	-	-
water	24,5	24,8	24,9	26,0	-	-	-	-
distensillimanite	-	-	-	-	66,7	66,7	66,7	66,7

concentrate								
ferrochrome slag	22,6	24,4	22,7	24,3	3,2	-	-	-
sodium silicofluoride	-	-	-	-		3,2	-	-
aluminous cement	-	-	-	-	-	-	-	3,2
liquid glass	-	-	-	-	30,1	30,1	30,1	30,1
Standard consistence	0,324	0,33	0,332	0,353	0,43[1]	0,43[1]	0, 43[1]	0, 43[1]
Initial setting time, min	5	9	10	170	20	25	70	100
Final setting time, min	15	25	135	195	30-35	37	175	210

Note: [1] The liquid glass to free-flowing components ratio.

Among the compositions on cement binders, it is most economically expedient to vary the time of setting the mixture when using Portland cement M400 (Fig. 3 and Fig. 4).

Significant reduction in the setting time can be achieved by adding liquid glass additives to the Portland cement (compositions 6-9). In this case, the most appropriate application of composition 7 with the addition of liquid glass is 11.9%, when the onset of setting occurs 17 minutes after the mixture is laid. Further increase in the amount of liquid glass in the mixture, although it leads to a further reduction in the setting time, but the mixture becomes non-technological because of its clumping.

Fig 3. The general view of the specimens of compositions 4-11 after determining the setting time

Fig 4. The general view of the specimens of compositions 12-20 after determining the setting time

The use of mixtures of gypsum and boric acid hardening accelerators (compositions 9, 10,13) does not allow achieving the setting time acceptable for laying the mixture with a 3-D printer. Furthermore, application of boric acid significantly lengthens the setting time.

The use of calcium chloride as an accelerator is effective only when it is contained in a mixture of 2.9% (composition 12), and initial setting time is 37 minutes.

The use of a combination of lime - calcium chloride is effective at a ratio of 2:1 and 1:1 (compositions 14,15), with the initial setting time of such mixtures is after 35-40 min.

It is interesting to use, as an accelerator, hardening of mixtures of soda (compositions 17-19). At the same time, intensive setting of the mixtures occurs, and the beginning of the setting of the mixtures begins already after 5-10 minutes. However, the use of composition 17 is not technologically advisable because of the difficulty in laying the mixture into a mold. Also, an additional introduction to lime soda is not advisable, since the time for setting the mixture is significantly increased.

The use of mixtures on a liquid-glass binder is most effective when ferrochrome slag and sodium silicofluoride are used as hardeners (compositions 21, 22). At the same time, the initial setting time of mixtures is 20-25 minutes, and the final setting time is 30-37 minutes.

Conclusions: To accelerate the setting time of mixtures on a binding agent as Portland cement, the use of liquid glass and soda additives is effective.

When used liquid glass as a binding agent, hardeners in the form of ferrochrome slag and sodium silicofluoride is effective.

REFERENCES

1. Construction 3D Printing, https://en.wikipedia.org/wiki Construction_ 3D_printing.
2. https://futureofconstruction.org/case/winsun/.
3. A. Kazemian, X. Yuan, E. Cochran, B. Khoshnevisac, Cementitious materials for construction-scale 3D printing: Laboratory testing of fresh printing mixture, Construction and Building Materials, Volume 145, 1 August 2017, Pages 639-647, https://www.sciencedirect.com/science/article/pii/S0950061817306657
4. T. Le, S. Austin, S. Lim, R. Buswell, Mix design and fresh properties for high-performance printing concrete, Mate. Struct. 45 (2012) 1221-1232.
5. Yi Wei Tay, Biranchi Panda, Suvash Candra Paul, Ming Jen Tan, Shunzhi Quian, Kah Fai Leong, Chee Kai Chua, Processing and Properties of Construction Materials for 3D Printing, Materials Science Forum, Vol. 861 (2016), 177-181.
6. Z. Malaeb, H. Hachem, A. Tourbah, T. Maalouf, N. Zarwin, F. Hamzeh, 3D concrete printing: mashine and mix design, Int. J. Civ. Eng. 6 (2015), 14-22.

CHAPTER VI
ECONOMY: PHYSICAL, CIRCULAR, GREEN

6.1. FOREIGN EXPERIENCE OF "GREEN CONSTRUCTION" PROMOTION AND POSSIBILITY OF ITS IMPLEMENTATION IN UKRAINE

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In modern society one of the most actual question is the threat of an ecological catastrophe that has reached the global level. Economic development has led to the rapid accumulation of physical and human capital through exhaustion and degradation of natural capital. There are many ecological problems which need the solution right now. The amount of environmental problems makes it necessary to develop and implement measures to all spheres of human activity. The importance of the topic raised for the first time was recorded in the Report of the International Commission on Environment and Development in 1987, in which the "sustainable development concept" was first defined at the international level. And the Climate Summit in Paris on December 11, 2015, started the real implementation of green technologies, environmental and economic concepts that were developed by many international conferences, where the principles and recommendations for a balanced solution of socio-economic objectives and the preservation of the natural environment and natural resource potential during the transition to sustainable development on the way to green economy were developed: Rio de Janeiro Conference (1992), Kyoto Protocol (1997), Development Finance Conference (Monterrey, 2002), World Summit on Sustainable Development (Johannesburg, 2002)

The main concept of each society is to ensure the normal mental development and preservation of human health. This is due to the progressive deterioration of the quality of the environment, on the one hand, and the stress-induced and immunosuppressive effects of the environmentally modified environment on the human body, on the other. The factors shaping the health of a modern person are distributed as follows: lifestyle - 53%, ecology - 21%, biology - 16%, health care system - 10%. In Ukraine, the unfavorable environmental state of the environment results in an increase in the ecological component of health to 60-70%. The RI-92 conference proposed a financial mechanism to support the new socio-economic system at the stage of its formation by allocating 0.7% of gross national income to industrialized countries to help exporting countries of raw materials.

All countries, with different level of activity, have started to introduce a new economic concept of the "green economy". An analysis of foreign experience has shown a rather positive perception of the new model both at the business environment and at the public level because it led to consensus over the long-term confrontation between environmental and economic interests, as well as the development of technologies has explained the link between economic growth and negative environmental impacts. In addition, it should be emphasized that today the construction branch is one of the most important branch of the national economy and plays a key role in prosperity of the whole national economy, so most often the construction industry and "green construction" created a multiplier effect for the development and further transition to eco-technologies of other sectors of the economy.

Green construction is the component of green economy. "Green" buildings have less negative impact on the environment than standard buildings. This is achieved through more efficient and rational use of resources, the use of alternative resources for the conservation of natural, waste processing. Those widespread use of "green" construction in the world can be one of the most effective tools for sustainable development of society. "Green" buildings are designed primarily to reduce energy and water consumption. You can reduce the consumption of these resources by an average of 25-30% and 30-50%, respectively. There is a lot of research that shows that the cost of designing and building "green" buildings differs little from the cost of designing and building conventional buildings. For example, the cost of constructing of 33 "green" buildings in Massachusetts is, on average, only 2% higher, and studies of more than 150 buildings that received the lowest rating in the US building system in the United States have shown that the construction of such a building is on average only 0.8% more expensive than building an ordinary building [1].

The state financial support for "green construction" projects in Germany is carried out by the national investment bank Kreditanstaltfur Wiederaufbau (KfW), which was established in 1948 to implement the Marshall Plan. The bank is in the shared ownership of the German Federal Government (80%) and land (20%) [2]. The main directions of KfW financing in the field of ecology are renewable energy sources, energy efficiency, low-carbon transport. In 2011, 22.8 billion euros were allocated for financing in the field of ecology, which is one third of the bank's financing of preferential programs and development programs. Supporting green projects, The Bank implements the following instruments [3]: cheap concessional lending by using several sources of borrowing; intermediary crediting; targeted subsidies for improving energy efficiency; assistance through the structure of the fund; guarantees and risk distribution through the on-lending system; sectoral guarantees; provision of external expertise. As a separate measure of state support for the financing of green construction in Germany is a preferential tariff program, which encourages investments in renewable energy sources, was first established in Germany in 1990, and in 2000 the Law on Renewable Energy Sources was accepted. Financing of this program is carried out through the distribution of costs for all consumers, which guarantees a low cost of electricity [4]. In addition to the state investment bank, there are several financial institutions in Germany that provide "ethical financial products" (environmentally and socially oriented) or "ethical banking": GLS bank, Triodos Bank, Umwelt bank, Ethik Bank.

The active moves towards a green economy in the United Kingdom began with the adoption of the Climate Change Act 2008, which aims to reduce carbon dioxide emissions by 80% by 2050 compared to the 1990 base year defining as well national environmental goals and the objectives of the European Union: the production of 15% of all energy from renewable sources (EU Renewable Energy Directive); processing of 50% of household waste by 2020 and reducing the landfill of biodegradable municipal waste by 35% by 2020 compared to 1995 (EU Waste Framework Directive). But the transition to a "green construction" in the UK requires significant investment. For example, in the field of energy (renewable energy sources, collection and storage of carbon, transmission of electricity, etc.), at least 100 billion pounds sterling is required; on renewable sources of heat - about 10 billion pounds sterling until 2020; on energy efficiency of houses - from 14 to 21 billion pounds sterling [5]. At the same time, the Commission of the Green Investments Bank (GIB) identified a number of barriers to the flow of investment in "green" projects in the UK: the limits of the capacity of the investment market and the limited capacity of the balance sheet; political and regulatory risks; lack of confidence among investors in view of technological risks, lack of transparency in public policy and high capital requirements for commercialization; the difficulty of attracting institutional investors to a large number of small low-carbon projects. The GIB was established by the UK government in 2012 to remove these barriers and attract investment in green projects. The main objectives of this institution are to eliminate the "failures" of the market and stimulate the flow of investment from the private sector into "green" infrastructure projects. The Bank uses next main instruments: loans and equity investments, financing through an investment fund and guarantees [6]. For today the GIB has committed 2.3 billion pounds sterling to 58 projects across several sectors, while mobilizing 7.8 billion pounds of private capital, and 1pound sterling contributed by the government accounts for 3 pounds additional private capital [7]. To support the green investments into construction, a market mechanism for "green construction" financing appears in the UK, which includes social responsible investment funds that finance social and environmentally oriented (ethical) projects and inform consumers about them. Along with the funds for social responsible investment, ethical (social and environmentally oriented) financial products emerged: current accounts, savings accounts, lending, insurance, mortgage, "ethical banking." These services are provided by the following financial institutions: Charity Bank, Tridos Bank, Ecology BS, Unity Trust, Naturesave, Golden Lane Housing.

"Green" financing in South Korea is carried out through bank loans and credit guarantees. It can also be carried out through the venture capital market. "Green" bank loans are provided through regular commercial banks and state financial institutions. In Korea, 75% of the "green" loans from the total amount are provided by state-funded banks. There are three types of "green" lending: direct lending, on-lending, a "green" deposit scheme [8]. Direct lending is carried out through government-financed banks directly to "green" companies. The scheme, where the government directs funds to commercial banks through the Korean Finance Corporation (Korea Finance Corporation, and then to the "green" companies, is called on-lending. In the "green" deposit scheme, the government does not participate directly, but offers tax incentives to those who invest at low interest in "green" projects. Credit guarantees are provided in South Korea by two main financial institutions: the Korea Credit Guarantee Fund and the Korea Technology Finance Corp. The Korean Export-Import Bank of Korea, which issued green bonds of $ 500 million for a five-year period with income of 1.75%, can also be separately identified [9]. In South Korea, there also is a system of "green" certification, includes two elements: The Green Certification Committee and the Korean Institute of Advancement of Technology, which determines which technologies and projects can be qualified as the "green", based on the assessment of the Korea Institute for Technology Promotion [10].

However, the transformational processes are not always initiated from the government, in some countries the initiative was "upwards”, and this is the actual experience for Ukraine in the conditions of decentralization. And this made the Canadian federal government develope the Federal Strategy for Sustainable Development 2016-2019, which covers the following topics: consideration of climate change and clean air; support for water quality and accessibility; environment protection; reduction of the impact on the environment [11]. According to a survey conducted by the Canadian Institute of Environmental Law and Policy, the following factors can be identified that constrain the transition to a green construction and the influx of green investments in Canada: the lack of leadership in the "green" economy at the federal level, which creates uncertainty and problems for business; lack of public understanding; tensions among and between stakeholders and government. Therefore, due to the lack of rich experience at the federal level, we will consider the experience of Ontario as the most active province in this area. In Ontario, one of the main problems in financing "green construction" is capital insufficiency, because, for example, the initial construction of renewable energy sources requires large investments, and the lack of federal support for these projects [12]. Based on the materials studied in Ontario, the following state support measures for green financing can be identified: Ontario green bonds, direct government funding through green funds, energy efficiency lending program, and a preferential tariff program. Ontario is the first province in Canada to issue "green" bonds to finance environmental projects (clean transport, energy saving and energy efficiency, clean energy, le agriculture, land management, adaptation and resilience to climate change.) The Green Investment Fund, which was funded from the provincial budget in Ontario, had become an organization that invests in green projects [13]. Another interesting example of government support for "green" projects in Ontario is the Feed-in Tariff, which was launched in 2009 to develop renewable energy sources, which would be used in construction branch.

Developed countries have been effectively implementing green building construction for a long period. The reason for this is the awareness of the benefits of green construction, environmental, economic and social. In Ukraine, the implementation of the green construction concept is at an early stage. As well as main part of businesses and citizens at the moment are not interested in additional costs for green constructing, the main driving force behind green construction promotion should be the state, having developed the appropriate legislative framework. This will become an important step towards creating an effective legislative framework in the field of green constructing, based on the requirements of the legislation of the European Union and the positive experience of foreign countries, will create conditions for efficient modernization of buildings, using of renewable sources in existing and new buildings, will promote the economic benefit of fuel and energy resources technologies implementation in constructing branch, introduction of mechanisms that will improve the ecological situation in the country.

On our opinion, there are several key directions for the implementing the “green construction” in terms of green economy. They are development of a legal act that would establish requirements for the construction of houses according to environmental criteria, stimulating the development of the production of effective and environmentally friendly equipment and materials, in particular the introduction of environmental taxes on building materials, development of measures to increase the demand for green buildings, in particular the development and implementation of a program for the formation of ecological oriented demand and increasing the environmental literacy of consumers, introduction of the green construction course into the educational process, raising the professional level of specialists engaged in construction, operation and designing and development of scientific support of green construction.

REFERENCES

1. Lockwood C. Building the Green Way. Harvard Business Publishing, 2006, pp. 129-135.
2. Wigley Ch. J. Chapter 15. Revitalising the Green Investment Bank, The Green Book: New Directions for Liberals in Government, ed. D. Brack, London: Biteback Publishing, 2013, 384 p., available at: https://books.google.ru/books?id=JwKuAwAAQBAJ
3. Hubert R., Cochran I. Public Finance Institutions & the Low-Carbon Transition Case Study: KfW Bankengruppe, CDC Climat Research, 2013, available at: http://www.i4ce.org/wp-core/wp-content/uploads/2015/10/14-09_kfw_case_study.pdf, p. 14-18
4. Mendonça M., Corre J. Success story: Feed-in tariffs support renewable energy in Germany, 2009, available at: http:// www.e-parl.net/eparliament/pdf/080603 %20FIT %20toolkit.pdf, p. 2-4
5. HM Government. Update on the design of the Green Investment Bank. 2011. URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/31825/11-917-update-design-green-investment-bank.pdf, p. 9-12
6. UK Green Investment Bank. Annual Report 2014. Edinburgh. 2014. URL: http://www.greeninvestmentbank.com/ media/25360/ar14-web-version-v2-final.pdf, p. 18
7. Department for Business, Innovation & Skills. Future of UK Green Investment Bank plc, Policy paper BIS/15/630, 2015, 24 p., available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477493/BIS-15-630-future-ofthe-uk-green-investment-bank.pdf, p. 10-11
8. System Architecture for Effective Green Finance in Korea, Korea's Economy, 2011, vol. 27, pp. 18–24, available at: http://www.keia.org/sites/default/files/publications/30848kimhtsp.pdf, p. 19-20
9. Korea Eximbank. Green Bond, Korea eximbank green bond newsletter, 2015, available at: http://ehf.koreaexim.go.kr/File.down?file=/attach_file/conts/kr/bank/Green%20Bond%20Investor%20Letter.pdf, p.1
10. OECD. OECD Economic Surveys: Korea 2012. 2012. 146 p. URL: https://books.google.ru/books?id=prlEtEgVnjkC, p. 99
11. Environment Canada. Planning for a Sustainable Future: A Federal Sustainable Development Strategy for Canada. 2010, available at: https://www.ec.gc.ca/ddsd/F93CD79500354DAF86D153099BD303F9/FSDS_v4_EN.pdf
12. Accelerating Ontario's Green Energy Industry, Financing Renewable Energy. 2010, available at: https://www. marsdd.com/wp-content/uploads/2011/02/MaRSReport-financing-renewable-energy.pdf, p. 15
13. Ontario Ministry of Finance. Jobs for today and tomorrow, 2016 Ontario Budget: Budget Papers, available at: http://www. fin.gov.on.ca/en/budget/ontariobudgets/2016/papers_all.pdf, p. 29-30

6.2. SIMULATION OF THE INTERACTION PROCESS OF THREE ENTERPRISES IN THE SINGLE PRODUCTION SYSTEM

Yershova Nina, Velmahina Natalia, Kovtun-Horbachova Tetiana

Nowadays in conditions of stiff market competition a great number of enterprises stop their functioning. Crucial importance in usage of limited productive resources has close and continuous interaction of enterprises in the single production system in the interests of gaining mutual benefit while taking joint decisions in satisfying the needs of society. Interaction of enterprises is characterized with a great number of different forces and means, mutually solved tasks and ways of their fulfillment, connections among them as well as a great deal of factors that determine the final result of their interaction – gaining of mutual benefit. So it is necessary to consider the enterprises' interaction with the position of system approach [1]. In order to solve the interaction of economic entities it is necessary:

- to justify general trend, principles of interaction and the requirements to them;
- to create the methodical apparatus estimating different ways of interaction and choice efficiency, optimal for each planned situation.
- to develop partial and general method of the interaction;
- to research the issues of management and organization of enterprises' interaction in the single production system.

With the position of the system approach the objects are not the subjects, but interaction among them.

In the work [2] a mathematical model of the production system was created that combines interacting companies. Research of dynamic processes of economic systems by different methods of optimal management was carried out in the work [3]. The production system is represented with two enterprises each of which produces gross output and spends labor, means of labor and objects of labor. The works [4 … 8] are devoted to usage the methods of optimal control theory for solving applied problems in the sphere of production and economic systems. In the works [9 … 10] analysis of interaction process of two companies that produce different products is carried out. By modelling in spreadsheets the efficiency of various ways of two companies' interaction was proved.

In the work [11] analysis of interaction process of three companies that produce different products was presented. The case when the intermediate product of each company is directed to the development of their own production and the final product is distributed among the enterprises was considered. By modelling it was proved that production system efficiency is higher in the case of equal distribution of the final production of the second company between the first and the third enterprise. The second enterprise builds dwelling houses, the first one produces metal constructions and the third one produces reinforced concrete constructions. It is obvious to make the second company funding and the first and the third ones the companies that produce interchangeable products.

In the work analytical research and simulation of interaction process of three enterprises producing different final products are carried out. The first company constructs dwelling houses and is funding, the second one produces metal constructions and the third one produces reinforced concrete constructions. Intermediate product of the funding enterprise is directed to development of its own production, final product is distributed among two other enterprises. Intermediate product of the second and the third enterprises is directed to development of their own production, final product is directed to external consumption.

Mathematical method of the production system that unites interacting enterprises can look like this:

$$\begin{aligned} &\frac{dm_i y_i}{dt} = v_i - v_{ai}, \quad y_i(t_0) = y_{i0}; \\ &x_i = k_i w_i; \\ &0 \le x_i \le y_i, \quad i = 1,2,...,n \end{aligned} \tag{1}$$

where x_i, y_i - flow of output and production capacity of the i- company; v_i, w_i - inflow of basic production assets and current assets; v_{ai} - outflow (amortization) of basic production assets of i - object; m_i, k_i - capital-output ratio and asset turnover ratio of the i - enterprise.

Production of all enterprises is measured in standard cost units.

Assumptions in calculation:

- flow of production of each enterprise is equal to its production facilities, so production facilities are used fully;
- capital-output ratio and retirement rate of basic production assets of enterprises are fixed;
- the rest necessary for functioning of enterprises is produced outside the system and doesn't limit its development, so it is sufficient and it comes in time.

Intermediate product of a funding enterprise is directed to development of its own production and final product is distributed between two other enterprises. The structural scheme of the enterprises' interaction is given in Figure 1.

In this case the mathematical model of three enterprises' interaction will be written as:

$$\begin{aligned} &\dot{y}_1 + a_{11} y_1 = 0, \quad y_1(0) = y_{10} \\ &\dot{y}_2 + a_{22} y_2 = a_{12} y_1, \quad y_2(0) = y_{20} \\ &\dot{y}_3 + a_{33} y_3 = a_{13} y_1, \quad y_3(0) = y_{30} \end{aligned} \tag{2}$$

where $a_{11} = \dfrac{\beta_1 - \gamma}{m_1}$; $a_{22} = \dfrac{\beta_2 - \gamma_1}{m_2}$; $a_{33} = \dfrac{\beta_3 - \gamma_2}{m_3}$; $a_{12} = \dfrac{(1-\gamma)\delta}{m_2}$; $a_{13} = \dfrac{(1-\delta)(1-\gamma)}{m_3}$,

$\gamma, \gamma_1, \gamma_2$ – the share of production flow that an enterprise leaves for development of its own production; β_i – retirement rate of basic production assets of i -enterprise; δ – the share of final product flow that is directed between the second and the third enterprises.

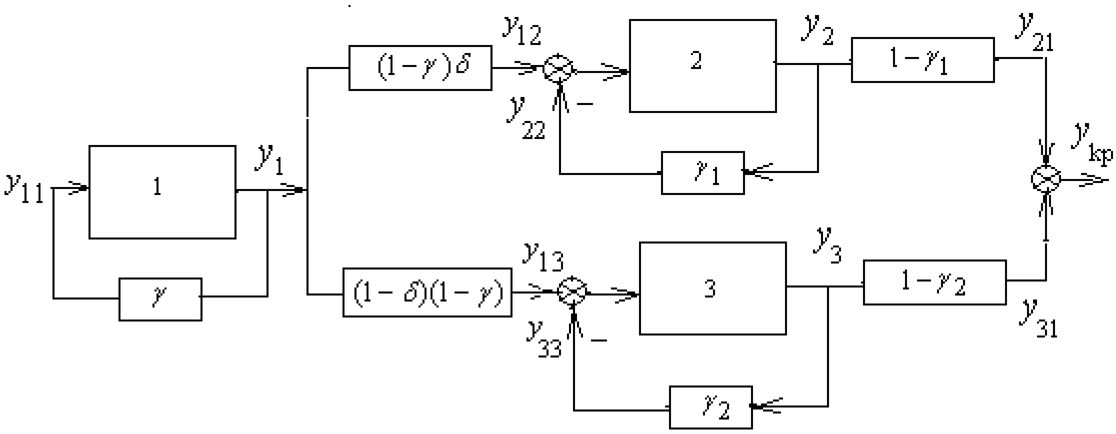

Fig. 1. The structural scheme of the enterprises' interaction

The solving of differential equation system (2) looks like:

$$y_1 = y_{10} e^{-a_{11} t}; \tag{3}$$

$$y_2 = (y_{20} - a) e^{-a_{22} t} + a e^{-a_{11} t}; \tag{4}$$

$$y_3 = (y_{30} - a_1) e^{-a_{33} t} + a_1 e^{-a_{11} t}, \tag{5}$$

where $a = \frac{a_{12} y_{10}}{a_{22} - a_{11}}$; $a_1 = \frac{a_{13} y_{10}}{a_{33} - a_{11}}$.

Equations (2) are written in the form convenient for modelling

$$\begin{aligned} \dot{y}_1 &= -a_1 y_1 + a_2 \gamma y_1; \\ \dot{y}_2 &= -a_3 y_2 + \gamma_1 a_4 y_2 + \delta a_4 y_1 - \delta a_4 \gamma y_1; \\ \dot{y}_3 &= -a_5 y_3 + \gamma_2 a_6 y_3 + a_6 y_1 - \gamma a_6 y_1 - \delta a_6 y_1 + \gamma \delta a_6 y_1, \end{aligned} \tag{6}$$

where $a_1 = \beta_1 / m_1; a_2 = 1/m_1; a_3 = \beta_2 / m_2; a_4 = 1/m_2; a_5 = \beta_3 / m_3; a_6 = 1/m_3$.

Simulation was made in the system of simulation STD 3.7 [12].

The program of simulation:

m_1=1,4; m_2=1,5; m_3=1,45; β_1=0,08; β_2=0,09; β_3=0,1; y_{10}=50уе/год; y_{20}=10уе/год; y_{30}=10 уе/год; δ=0,5; γ=0,7… 0,9; $\gamma_1 = \gamma_2$= 0,25 … 0,8.

Time of simulation is first 10 years of functioning of an enterprise.

The enterprise is operating sustainably, if $0{,}08 \le \beta \le 0{,}3; 0{,}2 \le m \le 4{,}9$ [13].

The scheme of simulation is presented in Picture 2, the results of simulation are given in Figure 3-8.

When comparing charts Pictures 4-6 one can stress that the maximum value all the indices obtain if the share of intermediate product of funding enterprise is 0.8. The maximum value of final product of the production system can be obtained if the share of intermediate product of the other enterprises is in the range of 0.65-0.75 (Figure 7-8).

Based on simulation major issues of organization of three enterprises' interaction in the single production system were developed. For sustainable operation of the production system and increasing its capacity the funding enterprise should leave 0.7-0.8 of the share of its output for development of its own production and

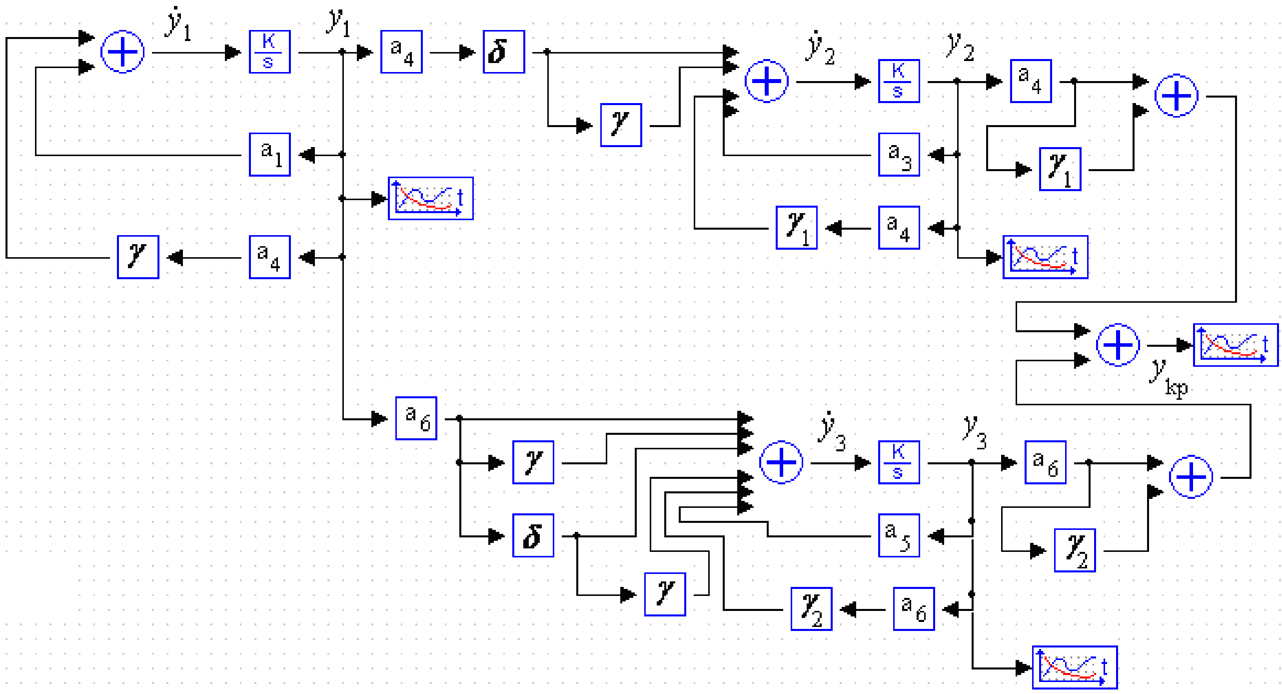

Fig. 2. Scheme of simulation

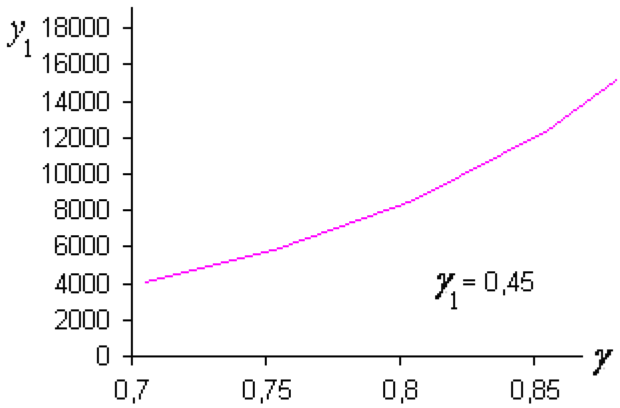

Fig.. 3. Capacity of the funding enterprise

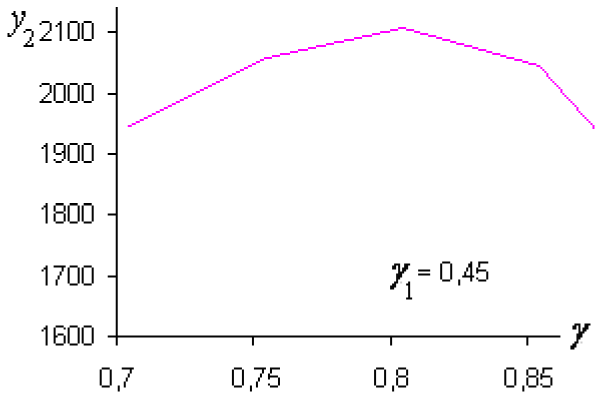

Fig. 4. Capacity of the second enterprise

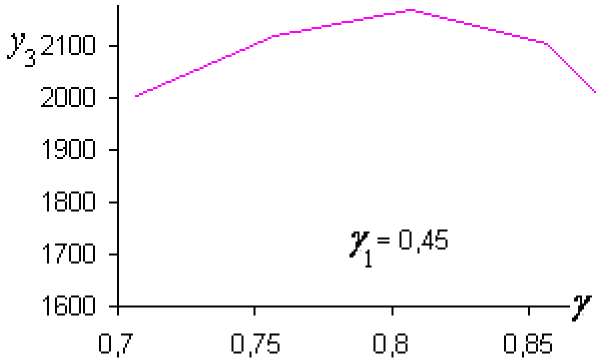

Fig. 5. Capacity of the third enterprise

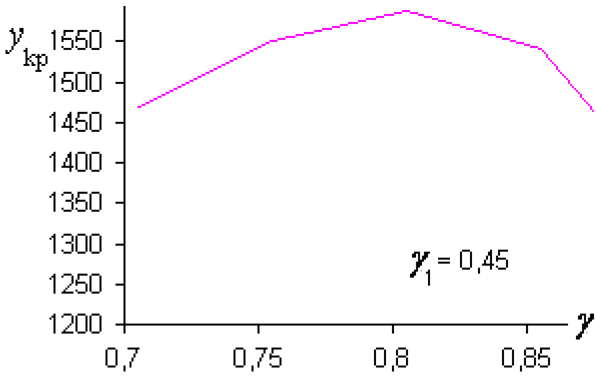

Fig. 6. Volume of final production of the production system

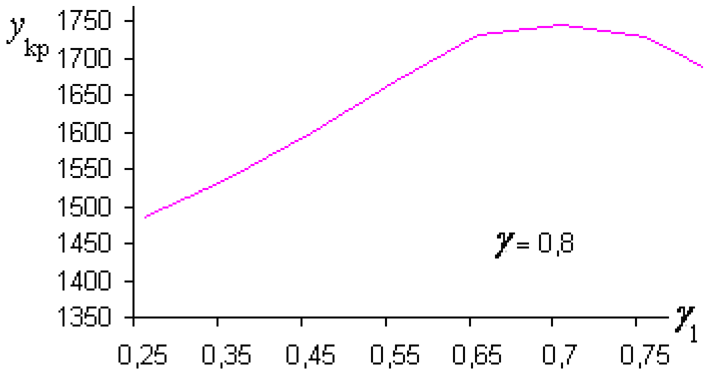

Fig. 7. Volume of final product of the production system

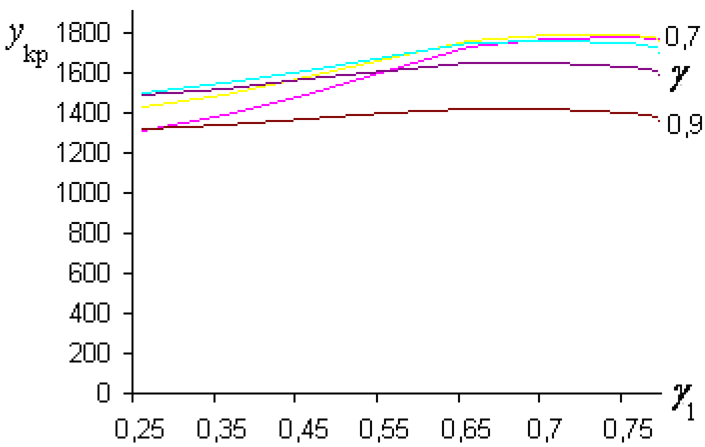

Fig. 8. Volume of final product of the production system

start its functioning with the maximum possible capital. In addition, the final product of the funding enterprise should be equally distributed between the second and the third enterprises to provide equal intense of its production capacity increasing. The second and the third enterprises should leave 0.65-0.75 share of its output for development of their own production and started to operate without external debts.

REFERENCES

1. Mikryukov V.Yu. *Teoriya vzaimodeystviya ekonomicheskikh subyektov* [The theory of interaction of economic subjects]. Moskva, Vuzovskaya kniga Publ., 1999. 96 p.
2. Sirazetdinov T. K. *Dinamicheskoy modelirovanie ekonomicheskich obyektov* [Dynamic modeling of economic objects]. Kazan, «Fan» Publ., 1996. 223 p.
3. Krotov V.F. *Osnovy teorii optimalnogo upravleniya* [Fundamentals of the theory of optimal control] Moskva, Vysshaya shkola Publ., 1990. 430 p.
4. Sotskov A.I., Kolesnik G.V. *Upravlenie dinamicheskimi sistemami v zadachakh ekonomiki* [Management of dynamic systems in the tasks of the economy] Tver, Tver. gosudarstvennyy universitet Publ., 2005. 120 p.
5. Kurshev V.N. *Teoriya upravleniya. Tekhniko-ekonomicheskie sistemy* [Control Theory. Technical and economic systems] Kazan, Kazanskiy gosudarstvennyy tekhnicheskiy universitet Publ., 2004. 134 p.
6. Kurshev V.N. *Teoriya optimalnogo upravleniya ekonomicheskimi sistemamy* [Theory of optimal control of economic systems] Kazan, Kazanskiy gosudarstvennyy tekhnicheskiy universitet Publ., 2003. 114 p.
7. Lagosha B.A. *Optimalnoe upravleniy v ekonomike* [Optimal management in the economy] Moskva, Finansy i statistik Publ.a, 2003. 192 p.
8. Berezhnoy L.N. *Teoriya optimalnogo upravleniya ekonomicheskimi sistemamy* [Theory of optimal control of economic systems] SPb, IVESEP, Znanie Publ., 2002. 64 p.
9. Ershova N.M., Gerasimenko S.V. *Analiz protsessa vzaimodeystviya dvukh stroitelnykh firm* [Analysis of the process of interaction between two construction firms]. *Visnyk Pridneprovskoy gosudarstvennoy akademii stroitelstva i arkhitektury* [Bulletion of the Dnieper State Academy of Construction and Architecture], 2008, issue 23, pp. 21-25.
10. Ershova N.M., Gerasimenko S.V. *Protsess vzaimodeystviya firm v proizvodstvennoy sisteme* [The process of interaction of firms in the production system]. *Materialy mezhdunarodnoy nauchno-prakticheskoy konferentsii «Perspektivnye razrabotki nauki i techniki – 2008»* [Materials of the International Scientific and Practical Conference «Perspective developments of science and technology – 2008»]. Przemysl, 2008, pp. 56-65.
11. Ershova N.M., Lavrenyuk I.V. *Analiz protsessa vzaimodeystviya trekh stroitelnykh firm* [Analysis of the process of interaction of three construction firms]. *Visnyk Pridneprovskoy gosudarstvennoy akademii stroitelstva i arkhitektury* [Bulletion of the Dnieper State Academy of Construction and Architecture], 2015, issue 10, pp. 52-56.
12. Kartashov B. A. *Sistemy avtoma-ticheskogo regulirovaniya* [Systems of automatic regulation]. Rostov-na-Donu: Feniks Publ., 2015. 458 p.
13. Shibko O.N. *Vybor osnovnogo pokazatelya kharakteristiki zhiznennogo tsikla stroitelnoy firmy* [Selection of the main indicator of the life cycle characteristics of the construction firm]. *Materialy vtoroy mezhdunarodnoy nauchno-prakticheskoy konferentsii «Dni nauki – 2006»* [Materials of the Second International Scientific and Practical Conference «Days of Science – 2006»]. Dnepropetrovsk, 2006, pp. 95-97.

6.3. SELECTION OF INDICATORS FOR RESEARCH INTO LIFE CYCLE PROCESSES OF CONSTRUCTION ENTERPRISES

Shibko Oksana, Spyrydonenkov Vitalii, Sokolova Kateryna

An enterprise, regardless of the form of ownership, industry and the scope of activity is subject to cyclic laws of vital activity and naturally does not avoid crises. The possibility of transition to higher stages of development or, on the contrary, to a fall in the crisis situations requires from leaders of an enterprise to change objectives, strategies and ways of their implementation [1]. Consideration of theoretical and practical processes of cyclic development of an enterprise, research into critical factors at different stages of the life cycle of an enterprise will make it possible to determine the differences in administrative actions and enhance efficiency of the anti-crisis management. That is why selection of indicators for studying the processes at different stages of the life cycle of an enterprise allows us to increase efficiency at the specific stage and to develop measures for prevention or lessening negative consequences and enhancing positive effects.

Based on the concept of a life cycle, enterprises emerge, develop, achieve success, get weaker and stop its existence. Some of them exist for an infinitely long time, but none exists in an unchanged form. New businesses are formed every day, at the same time, hundreds of enterprises are liquidated forever.

Studying the life cycle of an enterprise, it is possible to consider reasonable to unite similar points of view on the issue and to separate the most important approaches that deserve attention.

The first approach is based on consideration of the life cycle in terms of the technology of a particular enterprise. A crisis at an enterprise is a battle of two tendencies of its existence: operation and development. Operation is the maintenance of vital activity, preservation of the existing quality of a system, while development is the acquisition of a new quality in the face of a changing environment [5]. The basis of the struggle is so called in literature the law of decreasing effectiveness of evolutionary improvement of systems. According to this law, the relationship between expenses that are associated with the improvement of a product or a process and the results, obtained from investments are represented with similar curves of development. In the first half of the curve, the relationship between costs and results is directly proportional [4]. However, at the correspondent stage, approximation to the boundary limit for the given technology and a decrease in productivity growth rate begin. In this case, the improvement of particular technical solutions becomes economically inefficient or even impossible, that is, there comes a limit of an increase in effectiveness of the use of the relevant principle of action. It should be noted that the competition mechanism contributes to the fact that development does not reach the final stage of the cycle and new technologies start to originate and develop in the framework of the old ones [6]. Otherwise, the transition to the next development curve takes place. This approach is based on the objective law of development of systems and is common both for technical systems and for goods, services, market sectors, etc.

Another approach is based on consideration of the life cycle of a product, which, as noted by the majority of national and foreign authors, consistently passes through the phase of implementation, initial and subsequent growth, maturity and decline. In some cases, one can say that enterprises pass through the same stages of development as the products that they produce [7]. The main difference between the life cycle of an enterprise from the life cycle of a product is caused by the possibility of enterprise's operation in several directions or products, which makes it possible to achieve sustainable activity of an enterprise as a whole by combining the stages of the life cycle in relation to specific directions, i.e., to maintain it at the maturity stage. The timely modernization of an old product or bringing out to the market of new products that is to replace the goods that for some reasons lost their relevance, supports the vital functions of an enterprise. As a result, restructuring of the production and technical base, as well as the organizational structure takes place and the transition to the next level occurs.

The third approach involves the fact that the life cycle of an enterprise is considered as a change of life cycles of its competitive advantages. A competitive advantage passes in its development through 5 phases of the life cycle: origination, growth acceleration, maturity, growth slowing down and decline. That is why the timely emergence of the next cycle of a competitive advantage allows (up to the correspondent moment) maintaining vitality of an enterprise.

It is worth paying attention to the approach, in which the life cycle of an enterprise is considered in the form of a sequential change of competitive strategies that take into account the changes in the external environment.

Traditionally, it is common to represent the life cycle of an enterprise in the form of dynamics of output (outcome) in time, in the role of which can be played by production volume, revenues or financial result in the form of the profit. While researchers do not have any controversy on the results of functioning of the system by the stages of its life cycle, their views on structuring this cycle diverge. In various sources, researchers explore from three to ten stages of the life cycle of an enterprise. The most interesting is the point of view of Adises, who in the late 1980s proposed to subdivide all the stages of the enterprise's life cycle into two groups: growth and aging. Young enterprises are very flexible and mobile, but poorly controlled. When an enterprise matures, the ratio changes – controllability increases and flexibility decreases.

In my opinion, the life cycle of an enterprise is a more general concept, which is why it is necessary to consider it in interrelation with life cycles of both a product, and technology, demand and competitive strategies. In the national and foreign literature, all these concepts are represented separately, since they reflect development of different elements of the production-economic system [10]. However, due to the close connection between the elements of the system, it is justified to consider them for each particular enterprise as a whole, thereby implementing a system approach. At each stage of the life cycle of an enterprise, the life cycle of a product, technology, demand, competitive advantage and competitive strategy will play a relevant role. System approach to monitoring given cycles of the production-economic system will make it possible to control the activity of an enterprise and maintain a high level of vital activity.

If we take into consideration the points of view on this matter, presented in literature, the curve of the life cycle of the production-economic system can be represented as follows. Dynamics of an industrial enterprise can be displayed as the curve of the ratio between costs and results. In this case, the result of the activity in terms of value is income (revenue). Revenue is the source of financing the business activity: reimbursement of costs that were spent on production funds and formation of monetary funds and reserves of an enterprise. For this reason, a decrease or an insufficient increase in revenues are distinguished in the literature on crisis management as the main cause of insolvency of an enterprise. Revenues from sales of products include the following components: reimbursement of the cost of production and sale of products, including repayment of liabilities; payments to the budget; the profit of an enterprise. Therefore, an increase in revenue can be caused by both an increase in production costs and a simultaneous decrease in the part of revenue, and an increase in specific weight of the profit as part of revenue together with a decrease in costs. In the first case, despite the favorable dynamics of sale volume, there is a real decrease in the possibility of the extended reproduction, which, in turn, is accompanied by a decrease in the amount of future revenue. Therefore, in our view, the dynamics of a change in profit can promptly display the phase of the life cycle of the production-economic system. In this regard, it is advisable to use it as a practical tool of crisis management.

According to scientific concepts, the possibility of the crisis situation of an enterprise or an increase in probability of its occurrence exists in the transitional periods of development – between the cycle stages. That is, at the determined unfavorable coincidence of factors, a construction enterprise may become insolvent at any stage of the life cycle, which can lead to its elimination. Therefore, an enterprise can retain competitive advantages in the market and financial capacity only by predicting crises of development at each stage of the cyclic dynamics. Crises occur at different stages of development of an enterprise. To prevent a system crisis, it is necessary to timely detect the symptoms and identify the factors that will indicate the possibility of occurrence of a crisis exactly at the specified stage and to develop measures to eliminate and weaken negative consequences.

Any enterprise is a system, composed of interconnected elements, links, relations and is their integrity. A system can be in a stable or an unstable condition. The processes of development of a system are cyclic and not all processes are controllable. A growth in complexity of an organization and production requires reconstruction of management, its advanced development. The transition from one stage to another can be accompanied by various types of crises, caused by the influence of external and internal factors. Therefore, for the managers of an enterprise, identification of possible manifestations of crisis phenomena, determining critical factors can be the basis for development of anti-crisis measures at each phase of the life cycle of an enterprise.

Thus, the crisis management can be defined as a system of administrative measures and decisions on diagnosis, prevention, neutralization and overcoming critical phenomena. It must cover all stages of development of a crisis process, including its prevention. A system of crisis management has the properties that add a special mechanism to management: flexibility and adaptability, ability to diversify and timely situational response, as well as the possibility to efficiently use the potential of an enterprise and informal management methods. So, selection of indicators for researching the lifecycle processes at different stages of development of an enterprise plays an important role at each stage of the life cycle of an enterprise.

REFERENCES

1. Bolshakov, B. E. Systems analysis of the methods of designing and controlling sustainable development / B. E. Bolshakov, Y. F. Shamaieva // Internet-journal «Scientific studies», №4, 2012. — p. 1-13.
2. Bolshakov, B. E. System of universal measures – laws in the science of sustainable development / B. E. Bolshakov // Sustainable innovative development: design and control: vol. 7(4), 2011 /

Electronic scientific edition (journal). URL: http://www.rypravlenie.ru/?p=1080 (date of reference: 10.03.2014).

3. Yershova, N. M. Modeling of innovative activity of construction enterprise / N. M. Yershova // Construction, material science, machine building //Collection of sc. works. Iss. 37. – Dnipropetrovsk, PSACA, 2006. – p. 140-144.
4. Shibko O. N. Selection of basic indicator for characteristic of the life cycle of a construction company/ O.H. Shibko// Materials of the 2nd International scientific and practical conference «Days of science – 2006». – Dnipropetrovsk: Science and education, 2006. – Volume 7: Economic sciences. – 2006. – P.95-97.
5. Yershova N. M. Analysis of dynamic indicators of a company in a modeling system / N. M. Yershova, O. N. Shibko // Materials of the 2nd International scientific and practical conference «Days of science – 2006». – Dnipropetrovsk: Science and education, 2006. – Volume 7: Economic sciences. – 2006. – P.86-88.
6. Ivanov T. B., Pereverzev N. A. Development of theory of life cycle of an enterprise under modern conditions / Ivanov T.B., Pereverzev N.A // Bulletin of St. Petersburg state economic university, No. 1, 2016. – P. 75-81.
7. Dorogan N. D. Structure of capital and life cycle of companies / Dorogan N. D. // News of St. Petersburg state economic university, No. 3, 2014. – P. 87-90.
8. Gusieva T. I., Nekrasova N. V. Problems of strategy of restructuring of industrial enterprises under unsustainable market conditions // Relevant problems of economics and control: materials of International sc. conf. (Moscow, April, 2011).Vol. II. — M.: RIOR, 2011. — P. 91-95.
9. Nazarenko S. S. Methodological approach to determining life cycle stages of a company /Nazarenko S. S. // Bulletin of Tula state university, No. 1, 2014. – P. 82-87.
10. Ivashkovsky I. V., Yangel D. O. Life cycle of a company and aggregated indicator of growth / Ivashkovsky I.V., Yangel D. O. // Corporative finances, No. 4, 2007. – p. 45-50.
11. Cherkasova V. A., Smirnova I. N. Dependence of investment innovative activity of a company on corporative life cycle / Cherkasova V. A., Smirnova I. N. // Corporative finances, No. 2, 2012. – p. 45-57.

6.4. THE PHYSICAL NATURE OF ECONOMIC POTENTIAL

Borodin Maksim , Kirnos Olesya, Spiridonova Kira

The major cause of international companies' appearance is internationalization of production and capital based on productive forces development that outgrow national borders. Internationalization of production and capital gains a character of economic relations expansion through creating numerous overseas branches by the largest companies and transformation of national corporations in transnational.

Capital export is becoming the major factor in formation and development of international corporations. The specific causes of international companies' appearance are their cost-effectiveness due to large scale production in a number of industries. The necessity to survive in stiff competition causes production and capital concentration on an international scale. As a result, activities on a global scale become justified and possibility to reduce production costs and gain superprofit occurs.

Ukrainian economy is more and more influenced by global processes of the world economy. Large vertically and horizontally integrated holding companies and conglomerations as well as numerous relatively small groups of connected companies operate here. In conditions of globalization formation of control mechanism is an urgent question for divisions of large transnational companies in Ukraine. Corporate management issues, conflict of interests of companies' owners, managers and other interested parties are under close supervision of state institutions, stock market participants and other researchers.

Investigation of problems in international companies' activity is widespread among national and foreign scientists. However, in national literature little attention is paid to investigation of changes in approaches to formulating of international companies' competitive advantages and strategies of their realization under global processes [1-6].

The main issues clarified are formulation and combination of purposes and functions of a parent company while subsidiary company management as well as development of the models of taking decisions of a parent company. Effectiveness of such interconnection is fulfilled by means of difference in legislation regulating business activity, labor, taxing. International companies gain profit because of differences in the economic realities of countries. So, it is possible to say about movement of the resource potential and energy transformation.

As a rule, a parent company carries four main functions:

1) formation of corporate business portfolio;

2) increasing corporate portfolio effectiveness;

3) management of value and financial sources;

4) formation of relations with external environment: state, partners, clients, etc.

There are four general models of corporate centers. They are standard conceptual schemes that consider the essence of the approach to parent company's organization of activity.

Special characteristics that influence main functions, tasks and parent company's activity play an important role in each case. Therefore, it is necessary to adapt all the models to certain situations considering peculiarities of business and organizational structure of the holding.

On the one hand, there is a net holding consisting of independent business units that have weak links with the parent company. In this model options of the parent company involve financial control through control of business planning, budgeting, control over profit and cash flow formation as well as taking basic decisions "fire/hire" considering business unit heads and estimation of their work efficiency [11].

The parent company does not try to coordinate the business unit activity or search synergistic effect. On the other hand, there is an operator who develops only one business direction, but has some profitable divisions that operate in different regions or produce different goods.

In such companies the general director and employees take an active part in development of the strategy, its realization and coordination of closely connected activities.

International companies with complicated structures form their strategies on the level of business and the level of the corporation. The most important characteristics of the modern strategy of competitive advantages developing are scope of the corporate's activity that determine type of its business, level of interaction of its components that show the basis of the corporate's business units coordination and method of the scale and interaction management. International companies expand scale of their activity by means of internal development, merging and acquisition of the other structures as well as forming strategic alliance.

In the conditions of international business globalization, the most appropriate strategy of corporate diversification becomes a means to obtain additional benefits from the synergies arising between types of businesses or between businesses and individual corporate parent structure. The corporation that has chosen the strategy of diversification does not aim for interaction among types of business, but tries to create synergetic effect of financial and management character including all its business units. In the effective management types of business within the strategy of corporate diversification combine flexibility of separately operating structures with the advantages of mutual usage of financial resources.

This strategy is contradictive and has both advantages and disadvantages. Its advantages are gaining opportunities for activity at dynamic market, providing stable flow of financial inflows, avoiding double taxation by means of reinvestment of corporation's profit into new types of business, gaining additional benefits and compensation of low potential growth. The advantages of the diversification strategy are gaining unique possibilities at dynamic market, providing stable flow of financial inflow, avoiding double taxation due to reinvesting of profit into new businesses, gaining additional benefit and compensation of low potential growth. However, the strategy of diversification is not always an effective mean of compensation of low potential growth. It provides lower capital costs and generates high profit level.

Joint venture company using their partner's capital, technologies and licenses and gaining companies of different forms of property is dominating types of strategies of attraction new technologies by Ukrainian companies seeking to develop.

Effective modern structure of international companies is based on location of subsidiaries, affiliated branches and productions in different countries. Such companies can sell finished goods of international companies produce components and details as well as provide business and financial services. It is well-known that in this case profit is received as a result of production location in the countries with cheap labor force.

Effectiveness of such interaction that allows international company to receive profit relates to the difference in legislation that regulates business, labor resources, taxation, etc. Therefore, it is possible to say about movement of financial, labor and intellectual resources. An analogy with physics laws which hydropower station work is based on can be drawn as the energy transformation. Difference in water level before and after a dam allows to get electrical energy – transmission of potential energy into kinetic energy by means of water energy processing

According to the law of conservation of energy total mechanical power of the closed system remains unchanged:

$$E_{\mathrm{k}1} + E_{p1} = E_{k2} + E_{p2} \tag{1}$$

$E_{\mathrm{k}1}$ - kinetic energy at some time;

E_{p1} - potential energy at some time;

E_{k2} - kinetic energy at the next time;

E_{p2} - potential energy at the next time.

The law of conservation of energy can be shown like this:

$$\frac{\mathrm{m}v_1^2}{2} + mgh_1 = \frac{mv_2^2}{2} + mgh_2 \tag{2}$$

If there is friction force between the bodies the law of conservation of energy changes. Total mechanical energy changes equal force of friction. Let us consider free fall of the body from some height h1. The body is still moving (let us assume we are holding it), the speed equals zero, kinetic energy equals zero. Potential energy is maximal, because the body is above all above the ground than in condition 2 or 3.

In condition 2 the body has kinetic energy (because it has already developed speed), but potential energy decreased, as h2 is less than h1. The part of potential energy passed into kinetic. Condition 3 is the condition before stop. The body has touched the ground and the speed is maximal. The body has maximal kinetic energy. Potential energy equals zero (the body is on the ground).

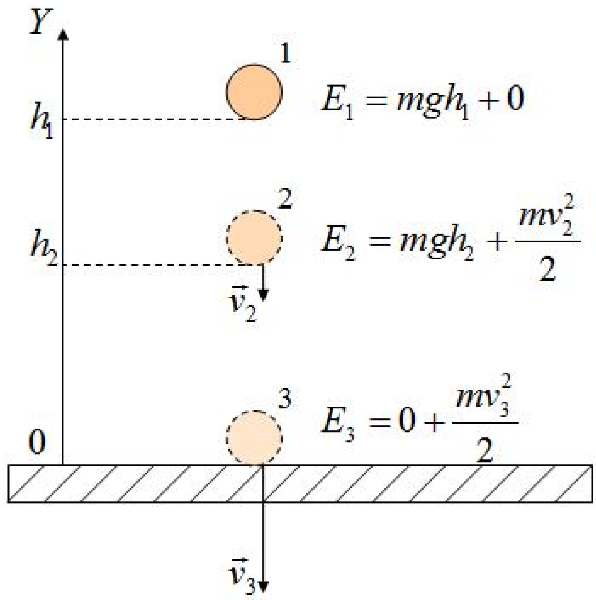

Fig. 1. Transformation of potential energy into kinetic energy

Total mechanical energy is equal if disregard force of air resistance. For instance, maximal potential energy in condition 1 equals maximal kinetic energy in condition 3. In view of the above it is possible to draw a parallel between physical processes and the processes that are the basis of international company's operation.

Any physical, economic, social and political forms of energy interactions arise out of nothing and do not disappear, but are only converted from one form to another.

Basing on the assumption that business combinations are a single organism combined with structural connection, it is necessary to unite all the enterprises in the single system when analyzing. Modelling of international companies' activity using physical (nature) laws of transformation of one energy into another will allow to get another approach to forecast some processes on which international companies' activity is based.

In the context of international business globalization, the most appropriate strategy of corporate diversification becomes a means to obtain additional benefits from the synergies arising between types of businesses or between businesses and individual corporate parent structure. The article draws parallels between the basic laws underlying the foundation and functioning of modern corporations and the basic physical laws. The article discusses the interaction of energy systems from the point of view of the energy conservation law and from the possibility of extracting scientific and practical use.

REFERENCES

1. Vakul'chyk O. M. Mekhanizm otsinky rezul'tatyvnosti diyal'nosti pidpryyemstv z korporatyvnym upravlinnyam : dys…. d-ra ekon. nauk : 08.06.01 / O. M. Vakul'chyk ; Nats. metalurh. akad. Ukrayiny. - Dnipropetrovs'k, 2004.
2. Holovkova L. Instytutsial'ni problemy rozvytku korporatyvnykh protsesiv v ekonomitsi Ukrayiny / L. Holovkova // Sotsial'no-ekonomichni problemy i derzhava. – 2011. – Vyp. 1 (4). – Rezhym dostupu do zhurn.: http://sepd.tntu.edu.ua/images/stories/pdf/2011/11glsveu.pdf.
3. Gubaydullina F. Pryamyie inostrannyie investitsii, deyatelnost TNK i globalizatsiya. / F. Gubaydullina // Mirovaya ekonomika i mezhdunarodnyie otnosheniya. – 2003. – # 2. – S. 42-48.
4. Pro aktsionerni tovarystva : Zakon Ukrayiny [pryynyatyy Verkhovnoyu Radoyu Ukrayiny] 17 veresnya 2008 r. # 514-VI // Vidomosti Verkhovnoyi Rady Ukrayiny. - 2008. - # 50-51. - St. 384.
5. Korporatyvni struktury v natsional'niy innovatsiyniy systemi Ukrayiny : navch. posib. dlya studentiv vyshch. navch. zakl. / za red. L. I. Fedulovoyi. – Kyyiv : Tsentr uchb. lit-ry, 2007. – 536 s.
6. Luk"yanenko D. H. Stratehiyi hlobal'noho upravlinnya / Luk"yanenko D. H., Kal'chenko T. V. // Mizhnarodna ekonomichna polityka. – 2008. – # 1-2. – S. 5-42.
7. Rabinovich A. Upravlenie holdingom: vozmozhnyie variantyi / A. Rabinovich, E. Krupskaya // Upravlenie Kompaniey : Ryinok tsennyih bumag. – 2003. – # 2 (21). – Rezhim dostupa: http://frshop.ru/library/458-upravlenie-holdingom-vozmojnyi-variantyi-almin-rabinovich-elena-krupskaya-upravlenie-kompaniey--g.
8. Savel'yeva T. Problemy rozvytku velykykh korporatyvnykh struktur v ekonomitsi Ukrayiny / T. Savel'yeva // Personal. – 2007. – # 9. – S. 12-15.
9. Sirko A. V. Stanovlennya i rozvytok korporatyvnoho sektoru v perekhidniy ekonomitsi : avtoref.dys. na zdobuttya nauk. stupenya d-ra ekon. nauk : spets. 08.00.01 «Ekonomichna teoriya» / Sirko Anatoliy Vasyl'ovych ; Kyyiv. nats. un-t im. T. Shevchenka. – Kyyiv, 2005. – 23 s.
10. Skopenko N. S. Teoretychni aspekty formuvannya intehrovanykh struktur / Skopenko N. S. // Ekonomichni nauky. Seriya : «Ekonomika ta menedzhment»: zb. nauk. pr. / Luts'k. nats. tekhn. un-t. – Luts'k, 2010. – Vyp. 7(26), Ch. 3. – S. 365-375.
11. Rayzberg B. A. Sovremennyiy ekonomicheskiy slovar / Rayzberg B. A ., Lozovskiy L. Sh., Starodubtseva E. B. – 3-e izd., dop. – Moskva : INFRA-M, 2000. – 480 s. – (Biblioteka slovarey "INFRA-M").
12. Rudyik N. B. Konglomerativnyie sliyaniya i pogloscheniya: Kniga o polze i vrede neprofilnyih aktivov : ucheb.-prakt. posobie / N. B. Rudik. – Moskva : Delo, 2005. – 224 s.
13. Shtundyuk V.D. FPG na orbite matrichnogo platezhnogo monitoringa / V.D. Shtundyuk // Finansyi i kredit. – 2000. – # 10. – S. 2-8 ; # 11. – S. 110-115 ; 2001. – # 3. – S. 3-11.

6.5. IMPLEMENTATION OF LOGISTICS METHODOLOGY WITHIN THE LIFE CYCLE OF THE PROJECT

Cherchata Anzhela

Nowadays the building companies should constantly solve complicated tasks connected with material resources management. So, effectiveness of the building companies functioning greatly depends on the integration of the systems of supply, production, transport and sales management. Failure in material and technical supply of the building process lead to the negative consequences: wrecking of building schedules, working hours losses, down-time of equipment, increasing of the construction cost, nonfulfillment of obligations, undermining of the company's prestige. Therefore, creating effective logistics system is very important for building companies.

According to PMBoK project management is based on management processes divided into five groups [1]: initiation, planning, implementation, monitoring, project management and completion. As a system functioning within the life cycle, project has an "input", a complex of interconnected processes and "output". Delivery of all the resources involved in the project takes place at the "input". "Output" if the result of the project.

Processes of project management overlap and are carried out during the whole life cycle of the project [2]. These peculiarities of processes of project management determine using logistics that allows to provide coordination of enterprises' activity to achieve the project objective depending on the stage of its life cycle.

Some scientists [3–5] refer logistic concept as the paradigm (the guiding idea) as platform of business support and tools for enterprises' resources optimization while management of main and cocurrent flows.

It is necessary to stress that logistization should be considered in applied aspects that allows to take into account the specificities of the branch. Considering this the authors [7–10] suppose that logistization of construction requires rationalization and optimization of economic flows as interconnected and interrelated processes of resource movement of participants of construction market to achieve social and economic goals.

Process control of any object must be based on system approach. It is necessary to consider an object or a subject matter, a methodology and method for management process as a system.

An object of logistic management is logistic flow as a complex of material, information and financial flows. A subject is effective organization of logistic flows based on synchronization of their interaction and synergy using [11]. Therefore the result of logistization usage is creating an effective logistics system where coordinated motion of flows providing rational business-processes operating during the whole life cycle of the project is fulfilled.

Logistic system is determined as an adopted system with feedback that performs certain logistic functions, consists of several subsystems and has connection with external environment [12].

With the increasing of economic flows intensification necessity in logistics usage for the building industry is up.

Effective using of logistical approach in the construction industry is provided by the following factors:

– Technological for providing non-stop duration of the building process, constant and full loading of manufacturing capacity;

– Economical, their basis is interdependence of financial and economical results of the activity of all the participants of the building process and their influence to the final economical results of the building process. The most important organizational and technical precondition for formation of stable macro logistical systems in the building industry is providing effective technology of building material and products manufacturing. It means one must provide the correspondence between characteristics of material, products, constructions and characteristics of their technology manufacturing, transportation and installation. Total technological flow of material resources is the sum of technology manufacturing, transport technology, installation technology, and operation technology.

Management of engineering and construction processes includes differentiation of material and connected flows on all the stages of the project life cycle within logistic system (Fig. 1). Conformity between the flows and certain business processes within the project is shown.

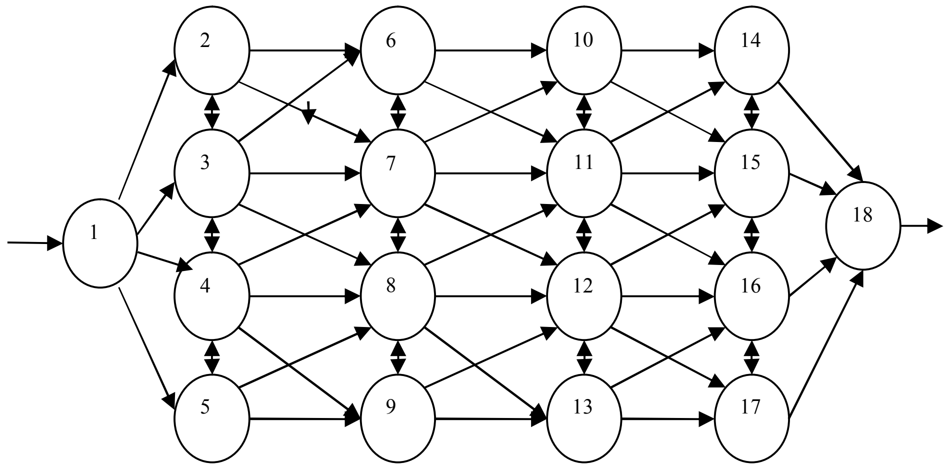

Fig. 1. Formation of construction enterprises' flows within logistic system during the life cycle of the project

Symbols:

1– input flow (resourcing of construction process);

2 – flow of the material resources (resourcing of construction process);

3 – flow of the financial resources (financial resources management);

4 – information flow (penetrates into all business processes of a construction company);

5 – flow of labor resources (provision of human resources);

6 – purchase of material and technical resources (resourcing of the building process; equipment and material procurement for production);

7 – payment of material and labor resources as well as information (financial flows management);

8 – designing estimates (design and prospecting operations and engineering);

9 – recruitment and training of the work force (human resources management);

10 – transportation, storage and industrial consumption of material resources (transportation of material resources, storage of stocks, constructions, products; production business processes, electricity, water, gas supply);

11 – payment of construction, installation and subcontract work (financial flows management);

12 – current calendar planning of the construction process;

13 – labor process organization (human resources management);

14 – sale of the building products (marketing activity management);

15 – payment for finished building products (financial flows management);

16 – advertisement and other informational and commercial communications marketing activity management);

17 – intracompany migration of labor resources and motivation (human resources management);

18 – output economical flows (construction operations, capitalized repairs, repair and construction work, mounting of engineering systems).

The model simplifies real economical flows of the building company and enables to observe its types and interconnections. In the model the material flow is shown as a complex of operations: 1-2-6-10-14-18; financial flow 1-3-7-11-15-18; informational: 1-4-8-12-16-18; labor: 1-5-9-13-17-18.

Decisions in the logistics are realized in MRP systems (Material Requirement Planning), DRP (Distribution Resource Planning – channels of distribution), ERP (Enterprise Resource Planning System), SCM (Supply Chain Management) [13].

As to the building industry MRP system in the automatic mode helps solve such tasks as:

– operational accounting and production stock and incompleted construction optimization;

– data base management while providing the manufacturing process with material resources and equipment;

– optimization of the working schedule according to the requirements of calendar building plan.

Implementation of MRP system involves the application of engineering allowing to form the team of experts responsible for a certain business process during the whole life cycle of the project.

Fig. 2 shows process of the building company's internal system reengineering while designing logistic system.

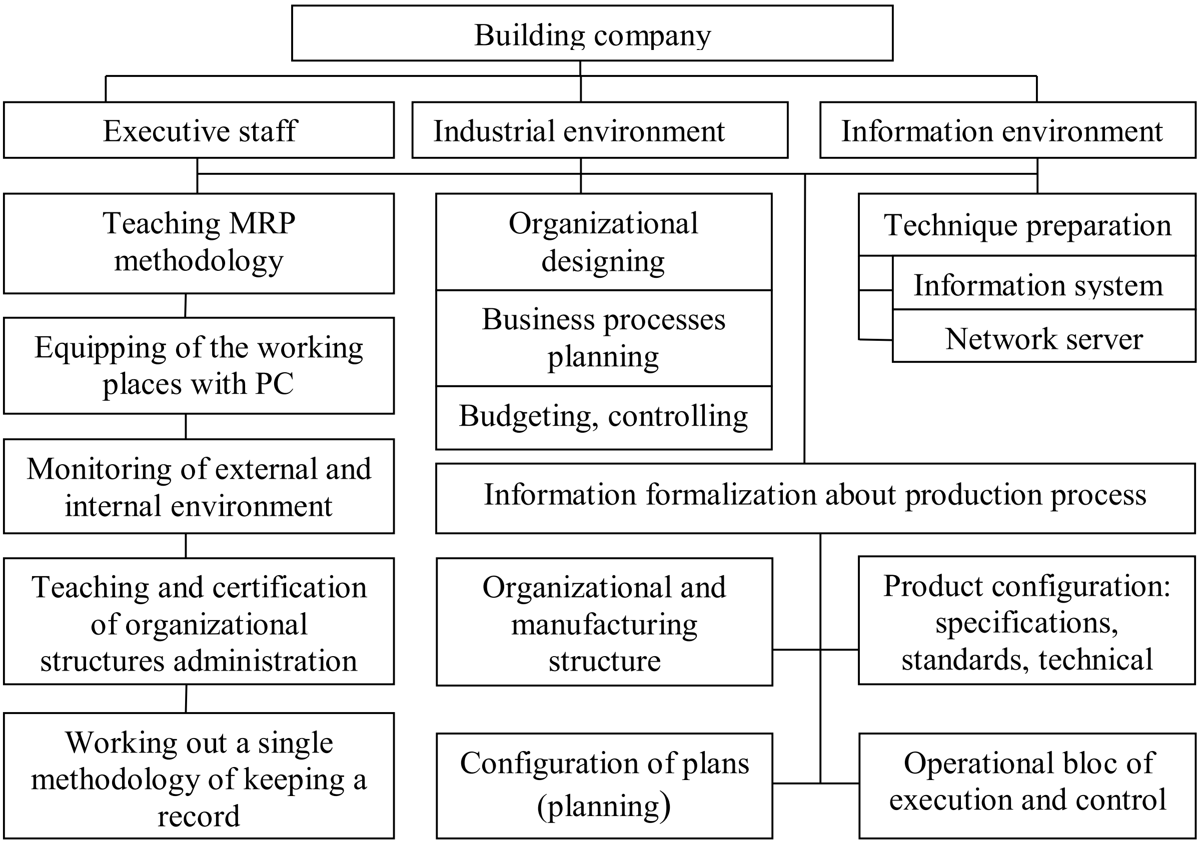

Fig. 2. Process of the building company's internal system reengineering while designing logistic system

As a result of the system above implementation (MRP-II) the following tasks must be solved:

– formation of the single informational base of the manufacturing process for production management;

– operational control over the material expenses according to the standards;

– operational management of stocks and purchases;

– automatization of production schedule formation;

– operational production management;

– optimization of manufacturing and labor resources usage;

– increasing of company's profitability.

Therefore, logistic management involves a complex of managerial functions, methods and form of project management. Their realization is directed to optimization of material and cocurrent flows within logistic system during the life cycle of the project.

Logistics implementation in the project management system allows to increase enterprises' activity within the project and gain competitive advantage.

REFERENCES

1. Rukovodstvo k Cvodu znanij po upravleniju proektami (Rukovodstvo PMBOK®) [A guide to the project management knowledge]. Project Management Institute. 5th edition. 2013, 586 p. Available at: http://www.studfiles.ru [Jelektronnyj resurs]
2. Bushueva N.S. Modeli i metody proektivnogo upravleniya programmami organizacionnogo razvitiya [Models and methods of projective management of organizational development programs]. Kiev: Nauk. svit, 2007, 199 p. (in Russian).
3. Chukhrai N. Innovatsii ta lohistyka tovariv: monohrafiia [Innovation and logistics of goods: monograph] Lviv: Natsionalnyi universytet «Lvivska politekhnika», 2001, 264 p. (in Ukrainian).
4. Krykavskyi Ye.V. Lohistyka. Osnovy teorii [Logistics Fundamentals of the theory] Lviv: Natsionalnyi universytet «Lvivska politekhnika», «Intelekt-Zakhid», 2004, 416 p. (in Ukrainian).
5. Karpova N.P. Lohystyka kak upravlencheskaia ynnovatsyia v rиnochnom prostranstve [Logistics as managerial innovation in market space] Экon. nauky, 2011, 4 (77), p. 71 – 75. (in Russian).
6. Radkevich A.V. Innovacionnye podhody k organizacii i upravleniyu material'nymi potokami stroitel'nogo kompleksa [Innovative approaches to the organization and management of material flows of the construction complex]. Visnik Dnipropetrovs'kogo nacional'nogo universitetu zaliznichnogo transport [Bulletin of Dnipropetrovsk National University of Railway Transport], 2013, 4 (46), p. 75 – 84. (in Russian).
7. Anoxin P.K. Principial'nye voprosy obshhej teorii funkcional'nyx sistem [Fundamental questions of the general the-ory of functional systems]. Moskva: Direkt-Media, 2008, 131 p. (in Russian).
8. Dragobyckij I.N. Sistemnyj analiz v jekonomike [System analysis in economics]. 2th edition. M.: JuNITI-DANA, 2012, 423 p. [in Russian].
9. Il'enkova N.D. Sistemnyj analiz konkurencii kak uslovie jekonomicheskoj bezopasnosti [System analysis of competition as a condition of economic security]. Jekonomika. Predprinimatel'stvo. Okruzhajushhaja sreda [Economy. Entrepreneurship. Environment.]. 2012, vol. 1, no. 49, p. 35-39 . [in Russian].
10. Tian R.B., Pavlov I.D. and Golovkova L.S. Upravlinnia proektamy u vyrobnichykh systemakh [Project management in production systems]. Zaporizhzhia: ZIDMU, 2006, 208 p. (in Ukrainian).
11. Frolova L. V. Lohistychne upravlinnia pidpryiemstvom: teoretyko-metodolohichni aspekty: monohrafiia [Logistics business management: theoretical and methodological aspects: Monograph] Donetsk: Donduet, 2004, 161 p. (in Ukrainian).
12. Hadzhynskyi A. M. Lohystyka: uchebnoe posobye [Logistics: a tutorial]. M.: Ynform.-vnedrench. tsentr «Marketynh», 2007, 408 p. (in Russian).
13. Lukynsko V. S. Modely y metody teoryy lohystyky [Models and methods of the theory of logistics]. SPb.: Pyter, 2003, 176 p. (in Russian).

6.6. UKRAINIAN AND FOREIGN PRACTICE OF CONTRACTUAL RELATIONSHIP

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Lately in Ukraine in development of the contractor's agreement some serious problems have occurred. Firstly, in development of the contractor's agreement the customer using forms of contractor's agreements (general conditions) makes an agreement of 4-5 pages. The interests of the contractor mostly were not considered, and adjustment of the contract clause were not often allowed. Secondly, lawyers but not specialists familiar with technology, organization construction economics started to draw up contracts. Lawyers must also take part in treaty-making, but after considering clauses concerning terms of construction, contract price, providing the construction with project documentation, materials, machinery and equipment, payment for completed work, etc. Their responsibility according to the contract is to provide fulfilment of the parties' obligations, risks, responsibility of the parties for violation of obligations and procedure of settling disputes. Experience shows that these issues are insufficiently worked out in contractor's agreement.

Nowadays rules of working out of contractor's agreement in capital construction are determined by General conditions of making and implementation of the contractor's agreement in capital construction approved by resolution of the Cabinet of Ministers № 668. While making a contractor's agreement for construction work it is necessary to guide the Civil and Economic Code of Ukraine. In addition to general conditions in 2009 Recommendations concerning drawing up enclosures to the contractor's agreement in capital construction were made up. In 2015 Ukrainian national standardization system N B A.3.1-33:2015 "Resolution according to preparation of making contact's agreement of engineering and construction work".

When drawing up the contractor's agreement the consumer can choose a form of the contract appropriate to the national or international practice of contractor's agreements of engineering and construction work. In the first case it is possible to draw up a contract based on the forms used in practice of European countries and the

USA (for example contracts of International Federation of Consulting Engineers – FIDIC, United Nations Commission on International Trade Law (UNCITRAL), European Economic United Nations Economic Commission, World Bank).

International form of the contractor's agreement can be used by agreement in non-governmental financing or under the conditions of credit arrangement for design and construction.

Preparing the contract based on international form the parties have a right to use international customs and recommendations of international organizations. The text of the contract must consider General conditions of making and using contractor's agreements in capital construction [1].

Standards of FIDIC have been used in Ukraine for more than ten years. For example, contracts on reconstruction of stadiums in Dnipro and Donetsk were drawn up using FIDIC contracts.

FIDIC contracts are used in construction projects, especially of international companies. These forms are also often used by international financial organizations while financing of large projects. If Ukraine is interested in attracting of international investors it is necessary to implement these contracts. These documents are rather simple and do not require making a separate contract from scratch. In a FIDIC contract the scenario of interaction of a consumer and a contractor, but both sides can change the form by mutual agreement. As FICID rules are known all over the world and absolutely clear, Ukraine has greater opportunities to attract monetary funds of international financial organizations to finance construction of infrastructure facilities [2].

The advantages of using FIDIC in Ukraine:

- international standards, the best practice of investment and construction projects realization;
- predictability, certainty and popularity for foreign partners;
- wide international acceptance (the World Bank, European Bank for Reconstruction and Development and other international development banks, transnational companies);

- flexibility and integrated approach to regulation, coverage of different stages and aspects of the construction project;
- implementation of different models of project management with the appropriate division of responsibility and balanced risks sharing (PC, EPC, DBO/BOT);
- lowering the project cost through effective management of quality, changes and risks mechanism, control of costs and the course of performance;
- saving resources and time for negotiation and contract preparation, tool for tender;
- continuity of construction process when concerns and uncertain situations arise;
- increasing the project's/company's expert's competitiveness on domestic and foreign markets, export of services, international integration;
- відповідність сучасним тенденціям посилення позицій експертних співтовариств і розширення сфери професійного самоврядування індустріями.
- conformance with modern trends of strengthening expert communities' positions and widening the sphere of industries' professional self-government.

The main problems when using typical FICID forms in Ukraine are connected with the absence of official translations in the Ukrainian language, algorithm of proceeding using FIDIC, lack of information of foreign consulting engineers about legal requirements and regulatory framework of pricing system in construction, lack of qualified independent control over construction.

The main problems of using typical FIDIC forms in Ukraine:

- lack of understanding of terminology, legal principles and status containing in FIDIC and their compliance with Ukrainian law;
- structural distortion, violation of the mechanism of their parts interaction (reduction and transformation, mistakes and omissions in drawing up special conditions and documents hierarchy, selectivity and inconsistency of changes, etc);
- material breach of balance of interests because of the changes;
- non-fulfillment of the demands of the Ukrainian legislation;
- lack of information of foreign engineers about local peculiarities badly defined coordination mechanism of interaction with local experts.

The courses if the problems of using FIDIC in Ukraine are:

- different legal systems and conceptual and terminological framework
- language barrier, absent or incorrect translation;
- excessive regulation by imperative norms of contractual sphere (the Economic and the Civil Codes of Ukraine, resolution of the Cabinet of Ministers № 668, forms KB-2V, KB-3, etc.) in addition to requirements of public law);
- lack of formed institution of consulting engineers, programs and training courses;
- state regulation in the sphere of control and supervising construction; lack of trust to expert's opinion and unwillingness to give him responsibility;
- breach of the contract, aim to minimize contract documents (confirmation are construction contracts on 4-5 pages with 20-26 articles);
- separation of the market players, lack of self-regulatory organizations and effective national association;
- insufficient integration to European and World construction and engineering community (FIDIC, EIC, FIEC) [3].

The Ministry of Regional Development of Ukraine is gradually solving these problems. For instance, Rules of determining construction costs of Ukrainian national standardization system N B D.1.1-1:2013 have been changed since January 1, 2014.

When estimating performed construction work that were financed by international financial establishments and approved by the Verkhovna Rada of Ukraine, typical forms of primary accounting documents "Reports of contractual work performed on a construction site for a month / year" (form№ 1), "Final report of performed work cost on a construction site for a period" (form № 2), form "Acceptance certificate of contractual work performed" (form № 3) are used.

On April 16, 2018 changes into Rules of construction determination of Ukrainian national standardization system b D.1.1-1:2013 were made. In the means of consumer service money for provision of services of consulting engineer in the case of his application (as a rule up to 3%) can additionally be included. The amount of the money above is accepted according to appropriate calculations. If foreign credits are attracted, received under state guarantees, on the phase of preparing investment design estimates funds to cover the costs of consulting engineering service are determined by calculation within the limits estimated using the index, if another one is not provided by the treaty. Spending costs is made on the basis of estimations according to specialist's manpower and cost of one working day and is agreed with the consumer [3]

Therefore, in Ukraine since 2018 an institution of consulting engineers has been introduced that allows to use FIDIC more successfully not only in international contracts, but also on large constructional projects of Ukraine adapting them to local terms.

This is just the first step using typical FIDIC forms in Ukraine. Reporting documents received as a result of FIDIC functioning allows to control work process and financing clearly and precisely equally defending the interests of a customer and a contractor (in contrast to construction contracts drawn up by the consumer without right of their adjustment and used in construction financed by the state).

In our opinion, implementation of FIDIC standards can bring positive effect due to creating of safe conditions for international investors, foster improvement of investment attractiveness of Ukraine in the world, revival of construction industry and economy in general.

REFERENCES

1. DSTU-NBA.3.1-33:2015 Nastanova shchodo pidhotovky ta skladannia dohovoriv pidriadu proektno-vyshukuvalnykh ta budivelnykh robit. [State Standart -NBA.3.1-33:2015 The instruction for the preparation and preparation of contracts for the execution of design and survey and construction work]. Kyiv, State Enterprise «UkrNDNTS» Publ., 2015. 23 p.
2. Prostota ta unifekatsiia: 7 pytan pro standarty FIDIC [Simplicity and unification: 7 questions about FIDIC standards]. Available at: http://cfts.org.ua/
3. Prakticheski-pravovoy aspect primeneniya preform FIDIK v Ukraine [Practical-legal aspect of the application of FIDIC's proforms in Ukraine]. Available at: uba.ua/documents/doc/grabchak.pdf.
4. DSTUBD.1.1-1:2013 Pravila vyznachennia vartosti budivnytstva (zdopovnenniamy ta zminami). [State Standart BD.1.1-1:2013 Rules for determining the cost of construction (with additions and changes)]. Kyiv, Scientific-Production Firm «Inproekt» Publ., 2013. 96 p.

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