Information about the unit in which the NIP is implemented

1. *Name.* Scientific and Technological Complex "Digital Engineering in Civil Engineering", World-class Scientific Center "Advanced Digital Technologies", Advanced Engineering School "Digital Engineering"
2. *Head of the unit - full name, academic degree, academic title, position, link to the individual profile (personal page) on the university website.* Vatin Nikolay Ivanovich, Doctor of Technical Sciences, Professor, Director of the Scientific and Technological Complex "Digital Engineering in Civil Engineering".
3. *The field of sciences and scientific directions within which research is conducted according to the International Science Map of the Olympiad.* Engineering and technology
4. *Topics of specific projects (implemented, executed)*
4.1. RNF Grant 24-19-00691 Prefabricated hybrid glass-basalt plastic composite pipe structures for temperate and Arctic conditions (2024-2026).
4.2. RNF Grant 24-44-20012 Engineering bioconcrete for self-healing. new biotechnology at industrial scale (2024-2026).
4.3. RNF Grant № 21-19-00324, Fundamental scientific research of new concretes with ash-free ash gravel with transition to clean and resource-saving energy and deep coal processing, 2021-2023.
4.4. Expert review of methods for assessing the load-bearing capacity of the suspension system. customer Armstrong World Industries LLC, 2023.
4.5. Research, analysis and updating of STO 73090654.002-2019 Methodical recommendations for insulation of building envelopes and pipelines of unheated attic with products of Knauf Insulation for normalization of temperature and humidity regime in unheated attics, customer Knauf Insulation LLC, 2022.
4.6. Study of thermal performance of elements of enclosing structures, customer JOSEPH GARTNER LLC, 2022.
4.7. Improvement of structural and technological solutions for construction of modular fast-erecting multi-storey buildings, customer FAU FTSS, 2022.
4.8. Strength performance study of the DiCom-Lift automated warehouse system, customer DiCom, 2021.
4.9. Project Manager, Determination of changes in the main performance characteristics of Crimean limestone stones treated with Oxal NK 100 stone-strengthening material produced by LLC "Em-Si Baukhemi", customer LLC "Em-Si Baukhemi", 2021.
4.10. State assignment of the Ministry of Education "Laboratory of Protected and Modular Buildings" (Scientific Topic Code FSEG-2022-0010), (2021-2027).

Topics and content of the NIP

1. *Name* - Digital Engineering in Civil Engineering
2. *Head of NIP - full name, academic degree, academic title, position, link to individual profile (personal page) on the university website*
Vatin Nikolay Ivanovich, Doctor of Technical Sciences, Professor, Director of Scientific and Technological Complex "Digital Engineering in Civil Engineering", https.//www.spbstu.ru/university/about-the-university/personalities/327148_vatin_nikolay_ivanovich
3. *The field of sciences and scientific directions, within the framework of which research is conducted in accordance with the International Science Map of the Olympiad*
Engineering and Technology
4. *The working languages of the research team in the implementation of the project* are English.

5. *Goals, objectives of the NIP*

Postdoctoral Program Objective

Development and implementation of science-based solutions to improve energy efficiency in construction, minimize negative environmental impact and create technologies aimed at resource saving, carbon footprint reduction and rational use of construction materials and natural resources. The program is focused on research aimed at practical application in the construction industry.

The main objectives of the program are

1. Energy efficiency of buildings

- Conduct basic and applied research on thermal storage, including the study of thermal insulation materials such as aerogels to reduce heat loss;
- Development of adaptive structures that respond to changes in external conditions to improve energy efficiency and building performance;
- Modeling and experimental study of air flows in ducts and caverns of building envelope systems to optimize ventilation and reduce heat loss;
- Development of design and experimental solutions to improve the energy efficiency of buildings, including the use of intelligent microclimate control systems.

2. Materials and structures for extreme environments

- Development of prefabricated structures made of glass-basalt-plastic composite pipes capable of withstanding difficult climatic conditions, such as low temperatures and high humidity, for applications in temperate and arctic regions;
- Creation of biocrete with self-healing properties to increase the durability of structures and reduce their maintenance costs, as well as the development of scalable technologies for its industrial production;
- To conduct research on the development of construction materials based on the recycling of industrial waste such as ash gravel to improve their environmental performance and affordability;
- Introduction of recycled materials and waste in the production of building structures to reduce waste and increase resource efficiency.

3. Resource saving technologies and environmental protection

- Development of methods for processing construction waste and its subsequent use as raw materials for the production of new construction materials;
- Developing solutions to reduce the carbon footprint in the production and operation of construction projects, including research into emission reductions at all stages of the materials lifecycle;
- Research and implementation of technologies aimed at rational use of natural resources and reducing the environmental impact of the construction industry;
- Life cycle analysis of construction projects to identify opportunities to reuse materials and improve overall environmental performance.

4. Interdisciplinary research and practical implementation

- Bringing together experts from materials science, building physics, engineering and architecture to develop integrated solutions that improve the energy efficiency of buildings and optimize construction processes;
- Collaboration with manufacturing companies to test developments, adapt them and implement them in real construction projects;
- Conducting educational activities to train specialists capable of creating and implementing solutions aimed at minimizing the use of resources and reducing the negative impact on the environment;

- Development of standards and recommendations for the introduction of energy efficient technologies and materials in the construction industry.

The program is aimed at integrating scientific research into construction practice, which will allow creating efficient and resource-saving solutions that meet the requirements of time and the demands of society.

Description of scientific approaches and methods, equipment for implementation of the NIP

In order to successfully achieve the goals of the postdoctoral program and meet its objectives, the use of modern scientific approaches and methods is expected. These methods combine advanced analysis, design and modeling techniques with practical experiments to create effective solutions in the construction industry.

1. Computer modeling techniques (CFD and engineering calculations)

Computer modeling, including numerical flow simulation (CFD - Computational Fluid Dynamics), will play a key role in building energy efficiency research.

- CFD allows you to model air and heat flows in and around building structures, analyze heat transfer mechanisms, and optimize ventilation, heating, and cooling systems.
- This method will help to study the airflow dynamics in the envelope structures including ducts and caverns to minimize heat loss.
- CFD will also be used to analyze the behavior of adaptive building materials and structures under extreme conditions such as low temperatures and high loads.

2. Digital Engineering

Digital engineering provides a framework for the development, analysis and optimization of building systems and materials.

- The use of specialized software for calculating mechanical, thermal and physical characteristics of building structures will allow predicting their behavior at various stages of life cycle.
- Digital engineering will combine engineering calculations, materials modeling and design development, minimizing the cost of physical experiments and accelerating design processes.
- The integration of digital engineering with computer modeling will ensure the development of high-precision solutions for the construction of energy-efficient and durable facilities.

3. Creating digital doubles

Digital twins are virtual replicas of physical objects that are used to analyze, predict and optimize the performance of building systems.

- The digital twins will be used to simulate construction projects at the design stage, as well as to monitor their performance under real-world conditions.
- With digital twins, it is possible to perform scenario analysis, identify potential problems, predict wear and tear, and perform performance optimization without the need for costly physical testing.
- This approach is particularly important for complex systems such as adaptive building facades or self-healing bioconcretes, where many interrelated parameters need to be considered.

4. Data integration and life cycle modeling

Numerical modeling and analysis techniques will be used to investigate the full life cycle of building materials and structures.

- Creation of life cycle models includes assessment of the environmental impact of each stage of production, operation and utilization of construction materials.
- Life cycle analysis will facilitate the development of materials with minimal carbon footprint and maximum resource efficiency.
- This approach will ensure the practical implementation of resource efficiency principles at all stages of construction and operation.

5. Experimental validation

Experimental studies will be conducted to verify the results of modeling and digital engineering.

- Laboratory testing of construction materials such as glass-basalt composites and self-healing concretes to validate their properties predicted by numerical models;
- Real tests on pilot construction sites to analyze the performance of innovative systems in the field;
- Comparison of simulation data with experimental results to adjust computational models and improve their accuracy.

The application of these scientific methods will integrate advanced modeling, analysis, and engineering technologies into the construction industry, providing energy-efficient, reliable, and environmentally friendly solutions.

Equipment

A list of equipment, materials, information and other resources.

1. For numerical calculations, the university's supercomputer center will be used. The computing environment of the center has a total peak performance of more than 1.2 PFlops and includes.

-heterogeneous cluster of 668 2-processor nodes with the latest 14-core Intel Xeon E5 2695 v3 and 64

GB of RAM; the peak performance of the cluster is 938 TFLops;

-unique computing system with mass parallelism and ultra-high multiprecision on Intel Xeon Phi processors, containing 256 nodes; peak performance of the system - 259 TFLops

-massively parallel supercomputer with cache-coherent globally addressable memory of more than 12 TB

and a peak performance of 30TFLops. Tasks will run on 4 Tornado Series direct liquid-cooled nodes, each with two Intel Xeon E5-2697 v3 CPUs v3 (14 cores, 2.6GHz) and 64TB of DDR4 RAM.

2. Access to Scopus, Web of Science, Science Direct databases, as well as to the full set of Overview, Benchmarking, Collaboration, Trends and Reporting modules of Elsevier's SciVal service.

3. The possibilities of the Information and Library Complex of SPbPU, which provides access to journals of Cambridge University Press, Nature Publishing Group, Springer, Taylor & Francis, John Wiley & Sons, as well as preserved access to scientific databases of the world's leading universities, will also be used.

4. List of basic equipment directly required to perform experimental studies of concrete specimens.

-Vika Matest E055N (Italy);

-Manual Blaine machine Matest E009-KIT (Italy);

-vibrating screen Matest A059-02KIT (Italy);

-adhesion meter Matest E142 (Italy);

-UWB-MG 4.01 watertightness test rig;

-laboratory drying cabinet CM 35/350 - 220 ШС;

-climate chamber SM - 55/50-120 SB;
-QUV veserometer (test climatic chamber) manufactured by Q-Lab Corporation;
-actinometric station;
-scales laboratory DA-1203C, BEL ENGINEERING, with verification;
-scales laboratory DA-6202C, BEL ENGINEERING, with verification;
-scales laboratory VM-313M-II, WESTA, with verification;
- moisture meter of construction materials VIMS-2.21 (LLC NPP "Interpribor");
-thermal conductivity meter ITS-1 (LLC NPP "Interpribor");
-thermal conductivity meter MIT-1 (LLC NPP "Interpribor");
-meter of thermophysical quantities Teplograph (LLC NPP "Interpribor");
-vacuum chamber GT 4.0.6;
- thermohygrometer TEMP 3.22 (LLC NPP "Interpribor").

The most significant equipment for the stated program.
1. Weathermeter TBT-XLW-150A (Fig. 3.2.1). The size of the test chamber is 350x300x300(h) mm. and the area of effective radiation exposure is ≈ 625 cm2.
The selected device allows for accelerated testing on.
-Lightfastness ;
-atmospheric resistance ;
-resistance to the combined effect of negative climatic factors.
The materials to be tested can be selected as.
-polymers and plastics;
-paints and protective coatings;
-textiles, including geotextiles;
-packaging materials;
-thermal insulation
Adjustable test parameters.
-Temperature. 0°C ... 70°C (±2°C);
-Black panel temperature. 45°C ... 85°C (±3°C);
-relative humidity. 20% ... 95% (±5%);
-radiation intensity. 150 ... 1200 W/m2;
-irrigation - sprinkling (presence or absence).
Measuring sensors.
-radiation intensity. UV radiometer;
-temperature. platinum resistance thermometer (PT100);
-Black panel temperature. bimetallic thermometer;
-relative humidity. psychrometric hygrometer.

2. Erstevak salt fog chamber
A device used to test the corrosion resistance of various items in an atmosphere with a high salt content. The products are placed in a chamber where they are exposed to a salt spray, which is created by spraying a salt solution onto the surface of the products. This determines how well the product is protected against corrosion and how long it can operate in a high humidity and saline environment.

3. Actinometer
An instrument used to measure solar radiation. The instrument makes it possible to collect detailed statistical data on the effect of solar radiation on the building envelope by obtaining time dependencies of the electromagnetic radiation of visible and ultraviolet light on time. the results obtained during periods with the longest or shortest daylight hours per year can be considered particularly informative.

Such a study has already been conducted by members of our team at the Lakhta Center Tower plazas. The actinometric station was placed in the buffer zone of the façade structure and recorded solar radiation receipts. Since buildings with a high percentage of glazing are characterized by high loads on cooling systems in summer, which leads to significant cooling costs, to improve the energy efficiency of such buildings it is important not only to properly design the thermal protection for the period of the coldest five-day period, but also to ensure proper operation during the summer period of increased temperatures and high intensity of solar radiation.

Postdoc Job Description

1. Tasks, functions in the NIP

The postdoctoral program offers scientists who have already completed their postgraduate studies the opportunity to deepen their research and acquire new competencies in the field of civil engineering. Participation in the program involves a set of tasks aimed at achieving the program goals and developing the postdoc's scientific career.

The main tasks of a postdoc.

1. **Conducting research and developing solutions.**
    - Performing fundamental and applied research related to improving the energy efficiency of buildings, developing adaptive structures and materials for extreme conditions.
    - Development and testing of prototype building systems such as prefabricated composite structures or self-healing biocrete.
    - Use of advanced computer simulation techniques (e.g. CFD) to optimize construction techniques and analyze thermal, mechanical, and physical processes in structures.
2. **Creating digital models and doppelgangers.**
    - Construction of digital models of objects under study, including buildings, construction structures and materials, to study their behavior under different conditions.
    - Development of digital twins to enable simulations and predictions of structural performance during the design and operational phases.
3. **Integration of data and results.**
    - Collection, analysis and interpretation of experimental data to validate the simulation results.
    - Implement methods for integrating data from different sources to create a generalized picture of the behavior of construction objects.
4. **Publication of scientific results.**
    - Preparation of scientific articles for publication in leading international journals.
    - Presentation of research results at international conferences and seminars.
    - Development of reports and recommendations for implementation of developments in industry.
5. **Participation in educational and scientific activities.**
    - Holding lectures, seminars and workshops for students and young researchers.
    - Facilitating undergraduate and graduate student learning through collaborative research.
    - Participation in the organization of scientific events, including conferences, round tables and symposiums.

Postdoc Functions.

1. **Research function.**
   The postdoc acts as a key executor of scientific research, ensuring its theoretical and practical implementation, including the development of hypotheses, performing calculations, modeling and experiments.

2. **Project Function.**
    - Participation in the formation of design solutions for new construction materials and technologies.
    - Maintain project documentation and coordinate interactions with industrial partners.
3. **Expertise Function.**
    - Conducting evaluations of experimental and research results.
    - Analyzing the applicability of the developed technologies and designs in real conditions.
4. **The function of scientific leadership.**
    - Mentoring of students and young researchers, including assistance in developing research topics and performing experiments.
    - Providing scientific support for joint research projects.
5. **The function of communication and popularization of science.**
    - Interaction with industrial partners to promote scientific developments and adapt them to practical use.
    - Popularize the scientific achievements of the program through popular science publications and participation in public events.

Postdoc perspectives.

Participation in a postdoctoral program provides the researcher with unique opportunities.

- Strengthening professional competencies in construction technology, materials science and digital modeling.
- Expanding the scientific network and establishing contacts with leading research centers and industrial enterprises.
- Creation of a base for the formation of its own scientific direction and participation in the realization of large-scale projects in the construction industry.

These tasks and functions will enable the postdoc to make significant contributions to science and technology and accelerate their implementation into practice.

2. *Rate, employment. job title, planned duration of contract (from 1 year)*.Research Associate, 1 year
3. *Salary (from 120,000* rubles per *month)* - 120,000 rubles per month
4. *Additional support (assistance in visa application, insurance and travel to the place of work, housing/rental assistance, academic mobility, Russian language courses, etc.)* - *assistance in visa application*, housing/rental assistance, Russian language courses*, etc.*
5. *Postdoc requirements*

A high level of professional competence, scientific experience and personal qualities are expected of a postdoc candidate to successfully fulfill the program objectives and achieve its goals.

1. Education and scientific qualifications.

- Possession of a PhD (or PhD) degree in one of the following fields. building physics, materials science, engineering, mechanics, thermal physics or related disciplines.
- Experience of working within a research framework, evidenced by publications in peer-reviewed international and national journals.

2. Knowledge and professional skills.

- In-depth knowledge of thermal engineering, building materials and energy efficient technologies.
- Proficient in computer modeling techniques including.
    - CFD (Computational Fluid Dynamics) for analyzing heat and air flows;
    - Finite elements for calculation of strength and thermal characteristics of building structures.
- Skills in developing digital models and digital doubles of construction objects.

- Experimental experience including laboratory studies of building material properties and structural testing.
- Ability to analyze data, interpret results and develop recommendations.

3. project and research skills.

- Experience managing or participating in scientific projects, including drafting project documentation and coordinating teamwork.
- Ability to conduct interdisciplinary research, integrate knowledge from different fields and propose innovative solutions.
- Ability to write scientific articles, design reports and presentations, prepare materials for conferences.

4. Communication skills and personal qualities.

- Ability to work in a team environment, including mentoring students and interacting with colleagues in related fields.
- High level of organization, responsibility and autonomy in performing tasks.
- Willingness to participate in conferences, seminars and other scientific events to present research results.
- English at a level sufficient for writing scientific articles and participating in international scientific events.

5. Benefits to the candidate.

- Experience working on interdisciplinary projects involving the construction industry, digital modeling, or materials science.
- Practical knowledge of energy efficient construction, sustainable materials or recycling technologies in construction.
- Programming or engineering software skills such as. ANSYS, COMSOL, OpenFOAM, SolidWorks, AutoCAD, MATLAB and others.

6. Willingness to work within the program.

- Participate in laboratory and field testing.
- Ability to complete assigned tasks within established timelines and program goals.
- Openness to new ways of working, including the use of advanced digital engineering and analytics technologies.

These requirements are aimed at attracting highly qualified specialists who can make a significant contribution to the program and the development of the scientific direction.

6. Expected results of the work (publications, RID, supervision of students, training of scientific personnel, participation in scientific conferences, etc.).

1. Publication of scientific articles in leading world-class publications.

- **Scientific articles**. Publication of at least 12 original scientific articles in peer-reviewed journals included in the databases Scopus, Web of Science or similar world publications with a high impact factor, which will confirm the high level of scientific work and innovativeness of the results obtained.
- **Publications in conference materials**. Presentation of research results in the form of scientific papers at leading international conferences to popularize new approaches and technologies in the field of energy-efficient construction, materials science and digital engineering.

2. Obtaining the results of intellectual activity (RIA).

- **Development and patenting of new technologies and materials**. During the postdoctoral program it is expected to develop solutions that can be patented as intellectual property, including new building materials, structural elements and engineering solutions aimed at improving energy efficiency and resource conservation.
- **Technological innovation**. Obtaining results that will be used in industry, such as new design methods, materials or technologies, and that can significantly improve the

processes of construction and operation of buildings under various climatic and operational factors.

- **Digital twins and models**. Development and implementation of digital twins for building design, operation and monitoring, which will contribute to a significant increase in the accuracy and efficiency of design solutions.

3. Participation in international scientific conferences.

- **Presentation of scientific results**. The postdoc will actively participate in international scientific conferences, symposia and seminars where she will present her research results in the format of oral presentations or posters. This will provide direct interaction with global experts and academic institutions, as well as facilitate the exchange of experience and the expansion of scientific contacts.
- **Networking**. Participation in scientific events will allow the postdoc to establish important connections with researchers and practitioners from the world's leading academic and industrial centers, which will further develop the research career and strengthen international scientific cooperation.
- **Publications in conference proceedings**. The results of conference presentations will be published in conference proceedings, which will also confirm the high level of scientific work.

4. Development of professional competencies and career.

- **Deepening scientific qualifications**. The postdoc will gain significant experience in interdisciplinary research and development to become an expert in energy-efficient construction and sustainable technologies.
- **Experience in research supervision**. The postdoc will also mentor undergraduate and graduate students, imparting research knowledge and skills that will contribute to the development of a research and educational environment.
- **Preparation for an independent research career**. Completion of the program will serve as an important step in establishing the postdoc as an independent researcher of high international standing, capable of independently conducting large-scale research projects and developing innovative solutions for the construction industry.