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Comprehensive approach to scientific and technical support of unique facilities at all stages of the life cycle

The modern construction industry is moving inexorably forward, constantly increasing the uniqueness of investment and construction projects. Unique objects, whether they are unique high-rise buildings or large-span ones, require a special approach at all stages of the life cycle of construction projects.

Scientific and technical support at all stages of the life cycle plays a key role in ensuring the safety, reliability and efficiency of such facilities.

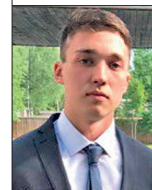
However, the lack of an integrated approach to the maintenance of such facilities can lead not only to an increase in project implementation time, but also to the risk of abnormal situations during the implementation of projects due to the failure to perform certain types of work within the framework of scientific and technical support.

This paper discusses the formation of an integrated approach to scientific and technical support at each stage of the facility's life cycle in order to minimize risks during the implementation of investment and construction projects.

Aims and Goals. Development and justification of an integrated approach to scientific and technical support of unique facilities at all stages of their life cycle. This paper is aimed at identifying key approaches that ensure effective process management within the framework of scientific and technical support, minimizing risks and improving the safety of unique facilities.

Materials and methods. The paper considers an integrated approach to scientific and technical support of unique facilities, which is based on the analysis of the regulatory framework, practical experience in project implementation, as well as the integration of theoretical and practical methods. The main focus is on the formation of methodology and fundamental principles, in terms of an integrated approach that ensures effective management of facilities at all stages of their life cycle.

Keywords: *scientific and technical support, methodology, construction, architectural and construction design, unique high-rise buildings and structures, buildings of class KC-3, construction and design of unique high-rise buildings and structures*



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INTRODUCTION

Modern trends in the construction industry tacitly lay the foundation for the development of various kinds of work, in particular, on scientific and technical support of unique buildings and structures.

According to GOST 27751–2014, p. 2.1.21: "Scientific and technical support: a set of works of research, methodological, expert, control, information-analytical and organizational-legal nature, performed by specialized research organizations in the process of research, design, erection, operation, reconstruction or dismantling of construction objects to ensure their reliability, safety, functional suitability and durability" [1].

The purpose of the article is to conduct a comprehensive approach to scientific and technical support, both at individual stages of the life cycle of the construction object, and the relationship of scientific and technical support between the stages: engineering surveys, design, construction and further operation of the object.

The peculiarities of the performed works, taking into account the specificity of unique buildings and structures, within the framework of STS survey and design, as well as the peculiarities of design of underground and above-ground components of the object are considered; the interrelation between

the results of STS P and STS C works is determined. Practical examples of realization of scientific and technical support at different stages of the life cycle of the construction object are given.

Unique objects are various buildings and structures that have additional requirements for design and construction, in this regard, one of the ways that affect, first of all, to ensure safety, is the mechanism of scientific and technical support (STS).

Conducting scientific and technical support should be comprehensive, in order to consider the most possible criteria and analyze the occurrence of different scenarios.

At the stage of pre-project work, the development of architectural and urban planning concept, it is necessary to analyze and determine the composition of work on the STS.

These works may include: modelling and "landing" of the building based on the results of the performed SGI, assessment of construction impact, development of recommendations to the programme of engineering-geological surveys, justification of possible deviations from the current regulations in terms of volumes and methods of surveys, analysis of archival materials in terms of engineering surveys, evaluation of the obtained data to ensure safe design [2].

Formation of the final set of works on STS will depend on the received initial data on the object.

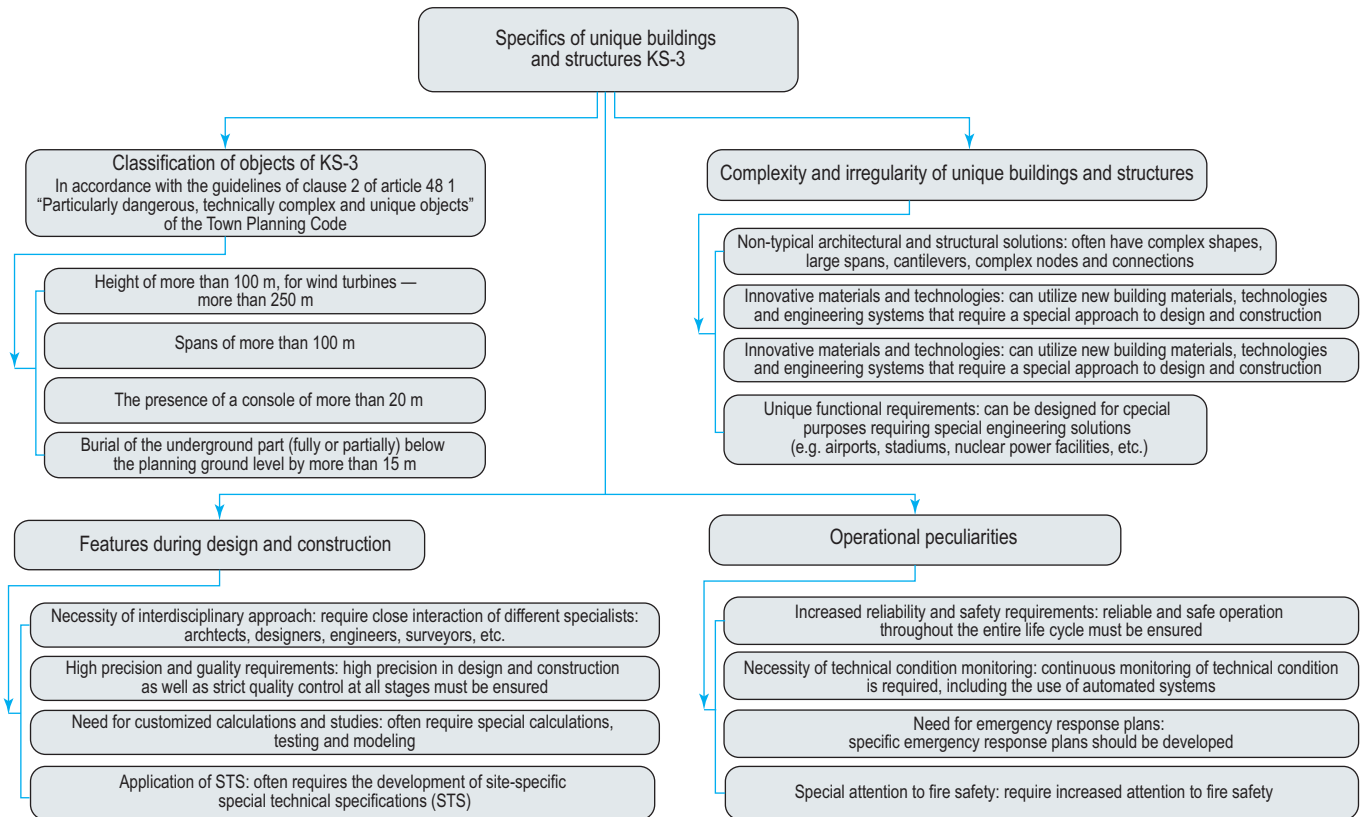


Fig. 1. Specifics of unique buildings and structures

Unique objects are buildings and structures that require a special approach to design and construction, and one of the mechanisms contributing to safety is the mechanism of scientific and technical support (STS) (Fig. 1).

The relevance of the study, in terms of STS, is also due to changes in legislation, in terms of design of buildings and structures, namely, the transition from the development and coordination of special technical conditions and approval of compensatory measures to the development and implementation of scientific and technical support [3].

The scientific and technical support should become comprehensive, in order to consider the most possible criteria and analyze the occurrence of various scenarios.

At the stage of pre-project work, the development of architectural and urban planning concept, it is necessary to analyze and determine the composition of work on STS.

Formation of the composition of works, which would be optimal and sufficient for scientific and technical support, is one of the most important stages, which, for example, may include a variety of works, including:

- development of recommendations to the programme of engineering-geological surveys;
- justification of possible deviations from the current normative documents in terms of volumes and methods of surveys;
- analysis of archive materials and previously performed surveys;
- evaluation of the obtained data to ensure safe design; modelling of geological environment reaction to earthquakes and development of a set of synthesized accelerograms for calculation studies of earthquake resistance of buildings and structures;
- development of additional requirements for the calculation

and design of buildings and structures of the facility taking into account the high seismic activity of the construction site and other dangerous natural processes, with the performance of verification calculations and quality control of the facility design [4].

Scientific-technical support during the construction phase is essential to improve efficiency, specifically, to reduce the amount of time required for the work. However, the regulatory documents partially reflect organizational and technical measures that can affect the efficiency of construction.

It is crucial not only to develop a methodology for providing scientific-technical support at various stages of the life cycle of an investment and construction project's life cycle, but also to conduct a comprehensive assessment to ensure the correct formation of the composition of the work performed [5].

A list of areas for analysis and further organization of scientific and technical support work.

1. Conducting a comprehensive assessment of the surrounding site development.

During the stages of conceptual design and the initial phase of project development, an integral part is the analysis of the immediate construction site and the surrounding area to identify and locate capital construction sites, cultural heritage sites, underground networks, and structures that cannot be dismantled, as well as other underground utilities that may affect the future progress of the project. This includes conducting various types of engineering surveys, as well as providing scientific and technical support for design and foundation engineering.

The analysis also involves verifying the accuracy of calculated soil models and calculating methods, performing foundation calculations when structures and foundations are working together, and



Fig. 2. Analysis of surrounding development

checking the bearing capacity and stability against the ascent of foundations of the stylobate section (Fig. 2, 3).

2. Carrying out STS works at the stage of engineering surveys (geological risk assessment, SIA)

The volume of construction of high-rise buildings is constantly increasing. In this regard, before the start of design and survey works, it is important to determine the necessary and sufficient list of both types of works and the composition of works directly on the engineering survey works.

In addition to the correct definition of the composition of scientific and technical support, within the framework of engineering surveys, there is a possibility of carrying out other works, depending on the conditions of the construction site or after the analysis of data obtained during the survey, for example, such works can be modelling the response of the geological environment to earthquakes, the development of a set of synthesized accelerograms to perform computational studies of earthquake resistance of unique buildings and structures, the development of additional requirements for calculation.

In this regard, the development of a comprehensive approach and the formation of a methodology for scientific and technical support of unique buildings and structures is an urgent problem that requires elaboration [6, 7].

3. Carrying out STS work at the design stage.

In the design of unique buildings and structures, several parts of the facility can be distinguished, viz:

1. Design of excavation enclosure structures.

2. Design of foundations and bases of unique buildings and structures.

3. Design of underground and above-ground parts of unique buildings and structures.

When constructing excavation enclosure structures for high-rise buildings, there are a number of peculiarities that need to be taken into account in the design.

High-rise buildings, as a rule, have an underground part made under the protection of the enclosing structure. The excavation enclosure structure (wall in the ground, sheet pile, etc.) located close to the foundation slab and buried below the bottom of the excavation can create (if one or more edges of the foundation of a high-rise building are located next to the excavation enclosure) an inhomogeneous (asymmetric) stress state in the foundation base, which changes the shape of the foundation slab deformation and causes additional building roll [8].

This impact of the excavation fence depends on:

- depth of the excavation, material;
- the depth of the excavation and the method of excavation fencing;
- dimensions of the excavation in plan;
- soil conditions;
- loads acting on the foundation from the building and other factors.

Given the high sensitivity of high-rise buildings to uneven settlement, the normative literature recommends that the high-rise building should be located in the center of the excavation.

In case of impossibility, its influence should be taken into account in the design by joint calculation of the foundation soil, excavation enclosure and building structures, including the foundation.

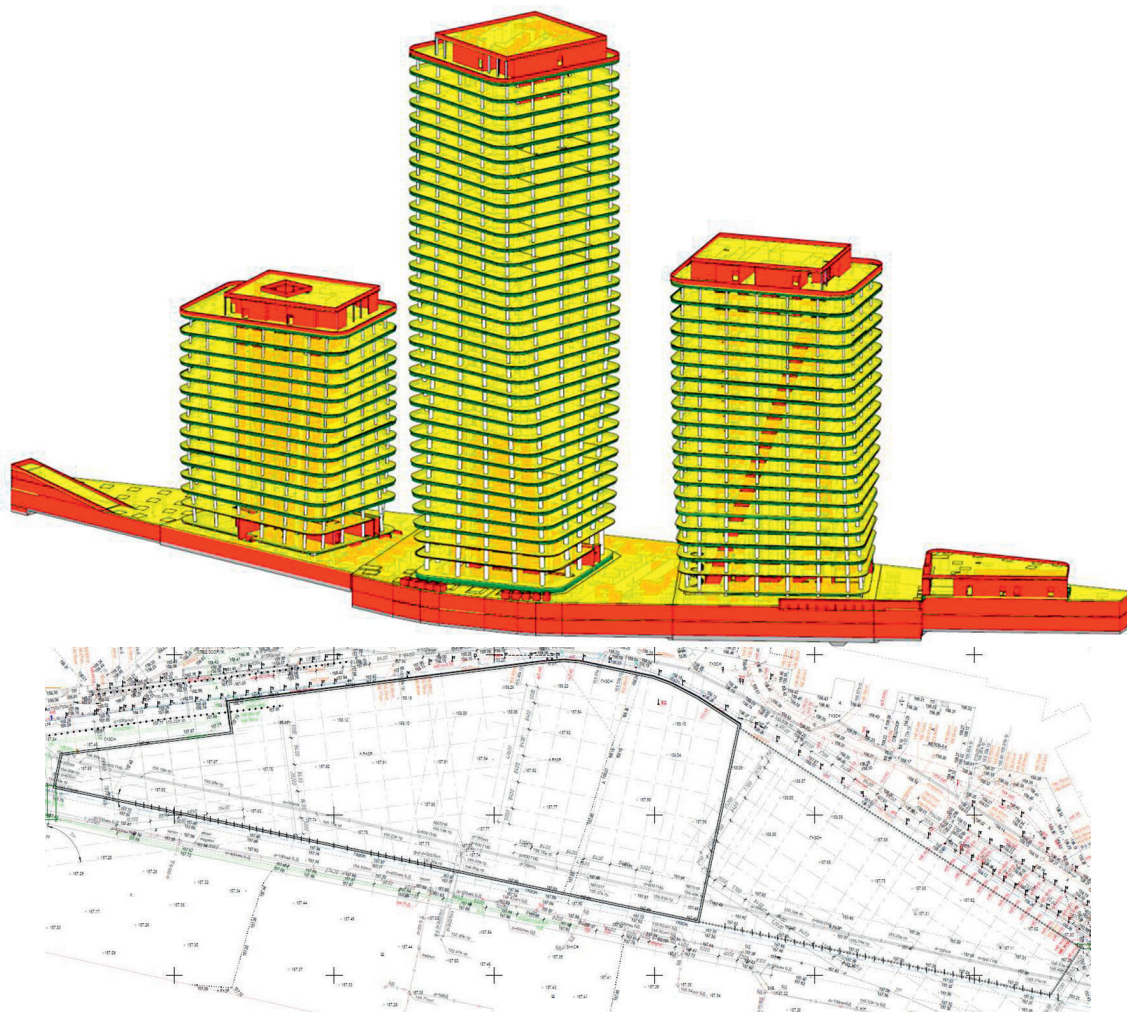


Fig. 3. Planting of the complex. Fencing structures of the excavation

When calculating the foundation, the method of construction of the enclosing structure is important.

Fig. 3 shows, as an example, the planting of a complex, which consists of multi-height buildings, next to the excavation enclosure.

In the construction of foundations of high-rise buildings there are a number of peculiarities that must be taken into account in the design, as well as in the scientific and technical support, within the framework of the design and working documentation, with subsequent recommendations for the work [9, 10]:

1. Due to the fact that the pressure along the foundation footings of high-rise buildings can be many times greater than for buildings up to 75 m high, this requires special survey work, as laboratory and field surveys.
2. The existing norms apply to the calculation of the bearing capacity of a pile up to 35 m long (resistance at the lower end of the pile) and up to 40 m long (resistance at the lateral surface). Since modern projects are characterized by significant height, this may not be sufficient for foundations of high-rise buildings, as the length of piles can reach 70 m.
3. Under significant loads (1–2 MPa) transferred to the substrate, it is necessary to take into account both the strength and deformation characteristics of rocky and non-rocky soils with

$E > 100$ MPa, which are considered in accordance with current regulations (CP 22.13330.2011)¹, as incompressible, as well as an increased stress distribution zone in the ground, both in plan and depth, which can lead to an increase in soil layers that absorb the load from the foundation. This can have a particularly strong effect if the layers are uneven.

4. An increase in the depth and width of the compressible layer in the soil leads to a longer time for soil consolidation to complete and a longer duration of the precipitation process.
5. If the foundation is built on soils with different coefficients of consolidation, both primary and secondary, it is important to consider the possibility that due to the uneven stress-strain state of the soil at the intermediate stage of consolidation, the consolidation of different types of soil may occur at the same time. This could lead to the building tilting beyond the limit values.
6. An increase in the size of the deformable area of the foundation can have a greater impact on surrounding buildings and structures, including water-carrying communications. This must be taken into account when calculating and carrying out work.

¹ SP 22.13330.2011. Soil bases of buildings and structures. Date of introduction 2011.05.20.

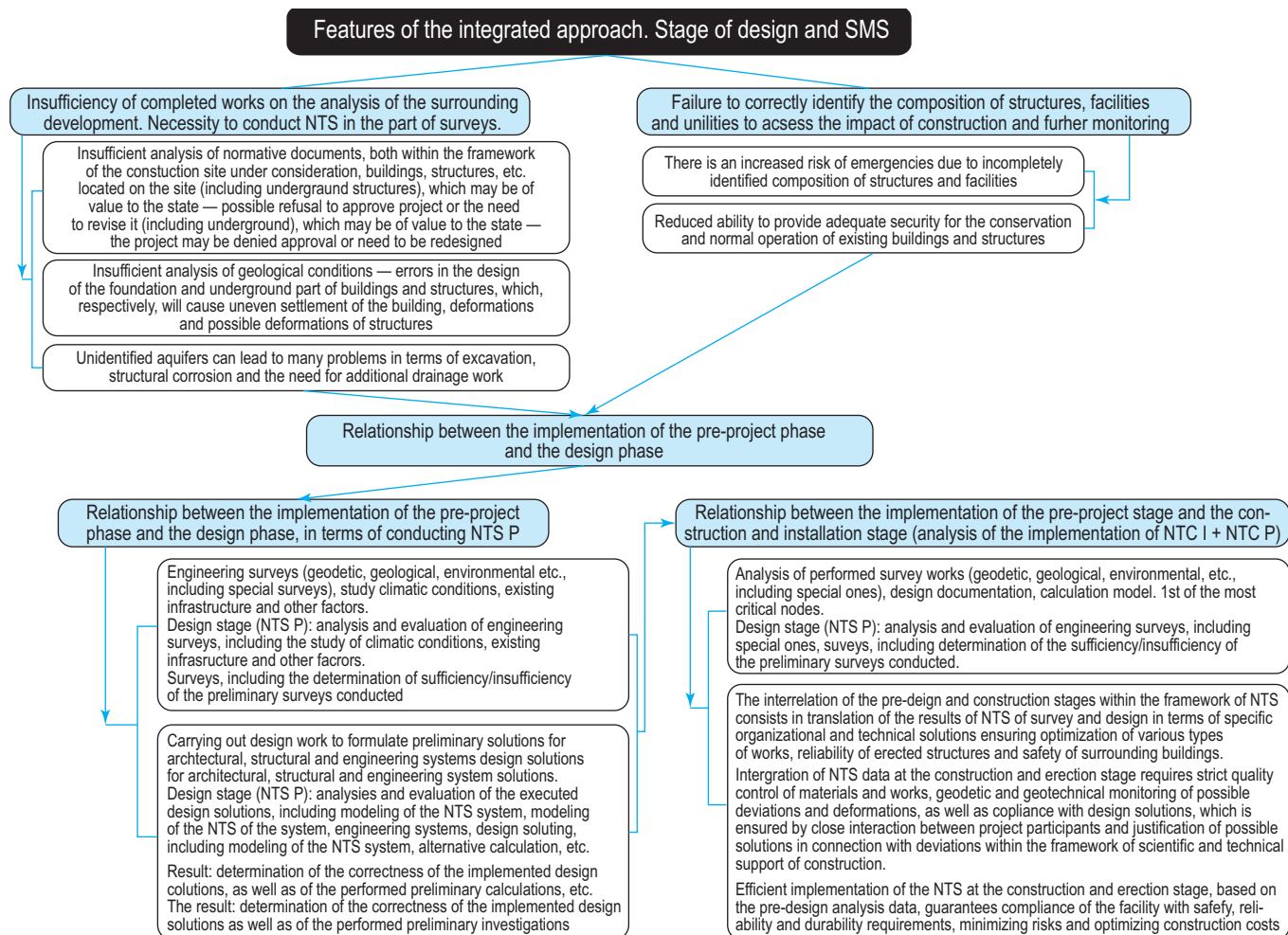


Fig. 4. Peculiarities of the integrated approach to conducting STS

During the construction of structures of the underground and aboveground parts of high-rise buildings a number of features arise that must be taken into account when designing [11].

1. Wind loads and aerodynamics:

- high-rise buildings are subject to significant wind loads, which can cause fluctuations and vibrations.

As part of the design and scientific and technical support, complex aerodynamic modelling is carried out, the aim of which is to provide recommendations on the assignment of aerodynamic coefficients for wind loads used in the calculation of load-bearing structures and enclosing facade systems of tall buildings of the facility. Additionally, the assessment of the level of relative wind comfort in pedestrian areas is conducted.

2. Vertical and horizontal deformations:

- shrinkage and creep of concrete: the need to take into account long-term deformations;
- temperature deformations: due to temperature fluctuations, stresses occur in structures;
- tilt and differential settlement: it is important to ensure an even distribution of loads on the foundation.

3. Fire Safety and Evacuation:

- fire resistance of structures;
- smoke protection, smoke-free stairs, and individual elements of buildings and structures;
- safety zones and elevators (including for evacuation purposes).

4. Architectural planning and energy efficiency solutions.

Carrying out scientific-technical support work at the construction stage

The main organizational and technical solutions, in terms of scientific and technical support during the construction phase, are [12, 13]:

- the formation of a work plan for the implementation of scientific-technical support for construction;
- development of recommendations for quality control of materials, joints, and fasteners;
- conducting control tests on materials, joints, and fasteners. Quality control of installed structures, including using instrumental methods, if necessary. Determining the scope of control within the scientific-technical support programme;
- providing scientific and technical support in solving technical issues arising during the construction of the building;
- quality control of construction and installation works (CIW) at all stages of the construction process, in accordance with the scientific and technical support programme or schedule, which forms an integral part of the scientific and technical support contract;
- control over compliance with the project for the construction of the building's structures, and, if necessary, development of proposals to strengthen or modify the structures;
- analysis of structural health monitoring data for a building under construction;

- assessment of compliance and performance of structures built with design deviations;
- development of recommendations to address identified structural deficiencies.

The programme of scientific and technical support during the CIW stage is formulated at the design phase, and it may involve an analysis of the solutions developed in the working documentation.

The implementation of scientific and technical support is primarily based on the provisions of GOST 27751–2014 [1] and SP 539.1325800.2024 [2].

To summarize, it can be said that providing scientific-technical support during the design phase of unique high-rise buildings is crucial, considering the complex and often individual characteristics of both the underground and above-ground components of such unique structures.

In order to ensure not only the necessary safety during the operation of unique buildings and structures, but also to optimize design solutions, it is important, within the framework of scientific and technical support of engineering surveys, to determine the necessary composition of organizational and technological solutions, thanks to which the stage of design and survey works will be the most effective at the stage of further operation, as well as — optimal for all project participants at the stage of direct design and survey works [14].

Scientific and technical support ensures that all factors affecting the correct implementation of projects of unique high-rise buildings are taken into account, which allows developing more effective design solutions. This contributes to minimizing risks, optimizing costs and improving the safety of the object at all stages of its life cycle (Fig. 4) [15, 16].

Thus, the relationship between the composition and results of scientific and technical support (STS) at the stages of survey, design and construction has been established.

This means that the results of STS at each stage (survey, design, construction) are interrelated and form a single system that ensures the continuity and consistency of solutions.

It is reasonable to perform scientific and technical support at all stages as a single set of works, including involvement of specialists who participated in the STS of survey and design in the STS of construction.

This is due to the fact that the features of the object identified at the stage of STS design (including forecast values, reserves and stocks) allow making more reasonable conclusions about the reliability and safety of the object at the stage of STS construction.

REFERENCES

1. GOST 27751–2014. Reliability of building structures and foundations. The main provisions. (rus.).

2. CP 539.1325800.2024. Scientific and technical support of engineering surveys, design and construction. General provisions. (rus.).

3. CP 20.13330.2016. Loads and impacts. (rus.).

4. Lapidus A.A., Topchy D.V., Shevchenko I.S. The concept of developing a programme model for scientific and technical support of the life cycle of unique buildings with a large depression. Bulletin of MGSU. 2022; 17(30):298-313. DOI: 10.22227/1997-0935.20223.298-313 (rus.).

5. Lapidus A.A., Shevchenko I.S. Defining the goals of the organizational and technological platform for scientific and technical support of unique objects. Construction production. 2023; 3:48-56. (rus.).

6. Lapidus A.A., Shevchenko I.S. Basic principles of forming an organizational and technological platform for scientific and technical support of unique objects. Bulletin of MGSU. 2023; 18(7): 1138-1147. DOI: 10.22227/1997-0935.2022.7.1138-1147 (rus.).

7. Lapidus A.A., Feldman A.O. Assessment of the organizational and technological potential of a construction project formed on the basis of information flows. Bulletin of MGSU. 2015; 11:153-156. (rus.).

8. Lapidus A.A., Shevchenko I.S. Definition of a set of measures for organizing and conducting scientific and technical support for unique facilities based on the formation of an organizational and technological platform. Construction production. 2024; 1:112-118. (rus.).

9. Shulyatyev O.A. Foundation engineering of high-rise buildings. Research Center "Construction". 2nd edition, revised and enlarged. 2016. EDN COAEYN. (rus.).

10. Lapidus A.A., Shisterova A.V. Consideration of the need for scientific and technical design support in the planning and implementation of design and survey work on facilities with a high level of responsibility. System technologies. 2019; 30:10-17. EDN UPLSMB (rus.).

11. Chen Zhaorong, Cai Zhili, Ke Biaozhi, Zeng Changluo. Several Structural Concepts of Reinforcement of High-Rise Buildings. American Journal of Civil Engineering. 2022; 10(6):213-220. DOI: 10.11648/j.ajce.20221006.11

12. Jung C., Awad R., Awad J. A study of optimal design process for complex-shaped skyscrapers' structural systems in United Arab Emirates. Ain Shams Eng. J. 2022; 13(5):101683. DOI: 10.1016/j.asej.2021.101683

13. Omrany H., Ghaffarianhoseini A., Chang R., Ghaffarianhoseini A., Rahimian P.F. Applications of Building information modelling in the early design stage of high-rise buildings. Automation in Construction. 2023; 152(8):104934. DOI: 10.1016/j.autcon.2023.104934

14. Davidyuk A.A. Scientific and technical support for the design of facilities with an increased level of responsibility. Industrial and Civil Engineering. 2020; 2:29-33. (rus.).

15. Levshin V.V., Kozelkov M.M. Regulatory and technical base of scientific and technical support of construction. Bulletin of SIC "Construction". 2020; 1:78-90. DOI: 10.37538/2224-9494-2020-1(24)-78-90. EDN WHRBXH. (rus.).

16. Evstigneev V.D., Kangezova M.Kh. Automation of organizational and technological aspects of scientific and technical support for the design of unique buildings. Bulletin of Tula State University. Technical sciences. 2021; 3:300-303. DOI: 10.24412/2071-6168-2021-3-300-304 (rus.).

Комплексный подход в рамках научно-технического сопровождения уникальных объектов на всех этапах жизненного цикла

Современная строительная отрасль неумолимо движется вперед, постоянно повышая уникальность инвестиционно-строительных проектов. Такие объекты, будь то высотные здания или большепролетные, требуют особого подхода на всех этапах жизненного цикла объектов строительства.

Поэтому научно-техническое сопровождение на всех этапах играет ключевую роль в обеспечении безопасности, надежности и эффективности таких объектов.

Однако отсутствие комплексного подхода к сопровождению таких объектов может привести не только к увеличению сроков их реализации, но и к риску возникновения нештатных ситуаций в ходе исполнения проектов в связи с невыполнением отдельных видов работ в рамках научно-технического сопровождения. В данной статье рассматривается формирование комплексного подхода к научно-техническому сопровождению на каждом этапе жизненного цикла объекта.

Цель. Разработка и обоснование комплексного подхода в части выполнения научно-технического сопровождения уникальных объектов на всех этапах их жизненного цикла. Данная статья направлена на выявление ключевых подходов, обеспечивающих эффективное управление процессами, в рамках проведения научно-технического сопровождения, минимизацию рисков и повышение безопасности уникальных объектов.

Материалы и методы. В статье рассматривается комплексный подход к научно-техническому сопровождению уникальных объектов, который базируется на анализе нормативно-правовой базы, практическом опыте реализации проектов, а также интеграции теоретических и практических методов. Основное внимание уделяется формированию методики и основополагающих принципов в части комплексного подхода, обеспечивающего эффективное управление объектами на всех этапах их жизненного цикла.

Ключевые слова: научно-техническое сопровождение, методология, строительство, архитектурно-строительное проектирование, уникальные высотные здания и сооружения, здания класса КС-3

СПИСОК ИСТОЧНИКОВ

- ГОСТ 27751–2014. Надежность строительных конструкций и оснований. Основные положения.
- СП 539.1325800.2024. Научно-техническое сопровождение инженерных изысканий, проектирования и строительства. Общие положения.
- СП 20.13330.2016. Нагрузки и воздействия.
- Лapidус А.А., Топчий Д.В., Шевченко И.С. Концепция разработки модели программы по научно-техническому сопровождению жизненного цикла уникальных зданий с большим заглублением // Вестник МГСУ. 2022. Т. 17. Вып. 3. С. 298–313. DOI: 10.22227/1997-0935.20223.298-313
- Лapidус А.А., Шевченко И.С. Определение целей организационно-технологической платформы научно-технического сопровождения уникальных объектов // Строительное производство. 2023. № 3. С. 48–56.
- Лapidус А.А., Шевченко И.С. Основные принципы формирования организационно-технологической платформы научно-технического сопровождения уникальных объектов // Вестник МГСУ. 2023. Т. 18. Вып. 7. С. 1138–1147. DOI: 10.22227/1997-0935.2022.7.1138-1147
- Лapidус А.А., Фельдман А.О. Оценка организационно-технологического потенциала строительного проекта, формируемого на основе информационных потоков // Вестник МГСУ. 2015. № 11. С. 153–156.
- Лapidус А.А., Шевченко И.С. Определение комплекса мероприятий для организации и проведения научно-технического сопровождения уникальных объектов на основе формирования организационно-технологической платформы // Строительное производство. 2024. № 1. С. 112–118.
- Шулятьев О.А. Основания и фундаменты высотных зданий // Научно-исследовательский центр «Строительство». Изд-е 2-е, перераб. и доп. 2016. EDN COAEYN.
- Лapidус А.А., Шистерова А.В. Учет необходимости выполнения научно-технического сопровождения проектирования при планировании и реализации проектно-изыскательских работ по объектам повышенного уровня ответственности // Системные технологии. 2019. № 30. С. 10–17. EDN UPLSMB.
- Chen Zhaorong, Cai Zhili, Ke Biaozhi, Zeng Changluo. Several Structural Concepts of Reinforcement of High-Rise Buildings // American Journal of Civil Engineering. 2022. Vol. 10. No. 6. Pp. 213–220. DOI: 10.11648/j.ajce.20221006.11
- Jung C., Awad R., Awad J. A study of optimal design process for complex-shaped skyscrapers' structural systems in United Arab Emirates // Ain Shams Eng. J. 2022. No. 13 (5). P. 101683. DOI: 10.1016/j.asej.2021.101683
- Omrany H., Ghaffarianhoseini A., Chang R., Ghaffarianhoseini A., Rahimian P.F. Applications of Building information modelling in the early design stage of high-rise buildings. Automation in Construction. 2023. No. 152 (8). P. 104934. DOI: 10.1016/j.autcon.2023.104934
- Давидюк А.А. Научно-техническое обеспечение проектирования объектов с повышенным уровнем ответственности // Промышленное и гражданское строительство. 2020. № 2. С. 29–33.
- Левшин В.В., Козелков М.М. Нормативно-техническая база научно-технического обеспечения строительства // Вестник НИЦ «Строительство». 2020. № 1. С. 78–90. DOI: 10.37538/2224-9494-2020-1(24)-78-90. EDN WHRBХН.
- Евстигнеев В.Д., Кангезова М.Х. Автоматизация организационных и технологических аспектов научно-технического сопровождения проектирования уникальных зданий // Известия ТулГУ. Технические науки. 2021. Вып. 3. С. 300–303. DOI: 10.24412/2071-6168-2021-3-300-304

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