The procedural approach to reliability of objects of the raised level of responsibility

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Abstract. The hypothesis of non-compliance presented in the regulatory methodology was grounded for building operations with the actual facility life of the facilities and buildings under the conditions of time lag. Briefly, the tasks for strategic development of the construction are presented in the following form: quality-reliability-safety-functionality-aesthetic qualities-amenities-economy. It is set that the listed tasks are multiplicative and require the systematic solution not only at the multidisciplinary but also at the transdisciplinary level. A comprehensive system “human-facility-technology-equipment-environment” is formed. It is established that the factor mutual interference of the elemental composition provides a possibility to implement the variable process approach of multi-modular modeling with component rating on the characteristic of marginality and accentuating. It is found that the absence of the single technical guidance on technical support of construction facilities of the increased level of responsibility at various stages of life-cycle. A structural model for technical support is prepared for construction of the increased level of responsibility. It is defined that the prognosis models for a 100-year-period functioning cannot be non-specific, they require the formation of the unique apparatus for evaluation of the initial characteristics of the facility that is adapting to changes of social-ecological-economic and technical paradigms during different time lags. A scheme is provided for categorizing the limit state of construction facilities, taking into account the factor impact and the responsibility of possible changes. The possibility of applying the combinatorial law towards the construction facilities is justified as to the comprehensive structured system with a functionally consistent and interdependent element base of a given finite set. Criteria maximum of the complexity profile in the existing structured system of construction facilities of the increased level of responsibility is proposed to consider parametric efficiency. The process approach to the development of research and development support for construction facilities of the I level of responsibility is based on the principle of anticipatory reflection of the validity of the safety parameter, the creation of an infographic model of a system with multiparameter characteristics of the life cycle stages. A mathematical model is developed for the change in the safety index of construction facilities of the increased level of responsibility as a system represented by an extended structure of components, with various impact factors at risk-rejection in a random segment of the operation period, and the concept of a "time lag" is introduced. Empirical indicator of the minimum value of the hazard severity is established and a proportionality coefficient having the dimension of the damaging factor is justified. It is proposed to apply the developed methodology as an addition to the development of research and development support programs, a model for verification by the level of responsibility and structured monitoring systems for different stages of the life cycle of construction facilities of the I level of responsibility.
1. Theoretical and practical background

The construction sector solves the strategic targets of the life support for the social, ecological, economic, technical, and technological character. The scale of the tasks basing on the programs and projects of the federal and region levels requires the search for optimal solutions with multiplicative effect. The general condition for the program implementation of production potential rapid development in the construction sector and its technical and material base is presented as a large scale resource enclosure for a new construction, upgrading or retooling.

Among the challenges of the innovation development of the construction sector, the factor of delay when implementing at all stages of the life cycle is identified, in terms of the organization of labor and its productivity; efficiency and resource saving of materials and technologies; ecological and social adaptation, etc. The main reason for what is happening is the inconsistency of the existing normative and regulating methodology of construction processes with actual operating life of facilities and buildings for a long time lag.

There is a lack of research, methodological and information support for the construction sector, which in turn negatively affects the choice of material and technical resources, schemes and technologies.

The tasks of strategic development of the construction industry are characterized briefly as quality-reliability-safety-functionality-aesthetic qualities-amenities-economy.

To achieve each of the listed criteria, the following is required strategically:
- creation of high technologies ensuring the effective use of the raw material resources basing on the fundamental and applied research with the use of top technical solutions of the related sectors;
- creation of price and quality competitive building types, materials and products taking to account the requirements for safety, ergonomics, hygiene, etc.;
- development of scientifically grounded recommendations on strategic targets of research and development policy, top fields of science and equipment, and effective mechanisms of their implementation;
- upgrading the economic mechanisms of performance efficiency increase of the construction sector by development and implementation of the strategic planning system, marketing and finance management;
- development and implementation of structural adjustment programs for construction sectors and its material and technical field in the context of the subjects of the federation and federal districts;
- development and implementation to all levels construction section functioning of local and global in-formation base and networks;
- information and analytical support on the direction of research and development progress;
- elaboration of development direction of research, development and innovative activity of production base of research, development and innovative activities of the production base of construction, road and technological engineering for enterprises and organizations of the construction sector.

Evaluation of the basic theories, methods and techniques shows that scientists in their studies also see the problem of reliability and safety of construction facilities of different levels of responsibility, in particular in the works [1-9], urban planning and regulation are proposed for the development of large cities to take into account the actions of self-regulation processes that allow for the ability of complex systems taking into account self-development.

In the work of Gusakova E A [10], in addition to the system approach in the design and management of the life cycle of a construction facility, it was proposed to introduce a genetic method that, in the opinion of the author, will significantly improve the efficiency of investment and construction processes in the context of accelerating changes in infrastructure and the external environment. Similar studies were carried out by Verigin Yu A [11], the use of synergetic foundations for the management of processes and technologies in construction production is proposed, which is complemented by the methodology proposed in the studies [12] for the formation in the hierarchical structure of system quanta of construction processes and the construction of facilities that ensure the
organizational and technological reliability of construction and in work [13], an analysis of structural changes in buildings and structures was carried out.

Baiburin A Kh [14] proposes to use an independent control of the accident risk, to introduce the insurance of the facility in the event of an accident, the control technology includes an accident risk assessment foreseen in the project (project risk) and the risk caused by erection defects.

In works [15, 16], the need for the development of CAD system for analyzing the impact of individual defects on the risk of an accident, clarifying models for the distribution of reliability indicators and conducting virtual tests of buildings and structures is substantiated. Research of Dontsov D G [17] became an addition to the basics of information support for the regulation of urban development systems, proposed a set of theoretical provisions adapted to the peculiarities of the Russian-transforming economy.

In the work of Smolyar N M [18], urban development is represented by separate entities, which in our opinion does not ensure system integrity when taking into account the reliability of the facility.

In the opinion of the authors of the article, the disjointed methods for solving the presented problems are multiplicative and require the expansion of the already existing systemic approach, rather than at the interdisciplinary level but at the transdisciplinary level.

To carry out the research, the hypothesis is accepted that, in justifying the reliability and safety of building facilities, a complex system of interaction "human-facility-technology-equipment-environment" is spontaneously formed, for which the factor interaction of the elemental composition allows for a variable process approach multiagent modeling.

**Survey objective:** conceptual baseline of the process approach to research and development support of construction facilities of the I level of responsibility for reliability and safety criteria at all stages of the life cycle.

**Research objectives:**
- Carry out research studies of regulatory documentation and the theoretical procedure in the field of establishing the composition and structure of programs for research and development support for construction facilities of the I level of responsibility;
- To substantiate the applicability of the variable process approach of multiagent modeling with the categorization of the components of the construction facilities of the I level of responsibility based on marginality and accentuation;
- Carry out structural modeling of especially dangerous, technically complex and unique construction facilities using basic scientific theories, methods and techniques with the establishment of limitations of their adaptability to the accounting of the parameters of changes in social-ecological-economic and technical paradigms in different time lags;
- Develop a mathematical model for changing the safety index of construction facilities of the I level of responsibility, with various factors affecting the risk-failure in a random segment of the operational period;
- Provide recommendations on the introduction of an additional methodology to the program of research and development support, the verification model for the level of responsibility and structured monitoring systems for various stages of the life cycle of particularly dangerous, technically complex and unique construction facilities.

2. Analysis of basic provisions of the regulation

Legal and regulatory framework is carried out in accordance with the requirements, as well as support standards and guidelines explaining the provisions in construction: Other paragraphs are indented (Bodytext Indented style).

- Federal Law of 23.08.1996 No. 127-FZ (as amended on 02.11.2013) "On Science and State Science and Technology Policy" (amended and supplemented, effective from 01.01.2014) (Moscow: Standard in form, 2014, 25 p.);
- Technical Regulations "On the Safety of Buildings and Structures" dated 30.12.2009 No. 384-FZ (as amended on 02.07.2013);
- "Urban Development Code of the Russian Federation" of 29.12.2004 No. 190-FZ (as amended on 18.06.2017);
- MS ISO 9001: 2015 Quality management systems. Requirements;
- ISO 91.040.01 GOST 27751-2014 Reliability for constructions and foundations. General principles. (Moscow: Standard In form, 2015. 16 p.);
  MNTKS GOST 31937-2011 "Buildings and structures - Rules for inspection and monitoring of technical condition". (Moscow: Standard In form, 2011. 95 p.);
  - TR 182-08 Technical recommendations on scientific and technical support and monitoring of construction of large-span, high-rise and other unique buildings and structures. (M.: LLC "UIC" VEK ", 2006. -26 p.).
  - MRDS 02-08 Manual for scientific and technical support and monitoring of buildings and structures under construction, including large-span, high-rise and unique. (M.: OJSC "KTB ZhB", 2008. -76 p.)

The analysis of the regulatory documents presented above revealed the absence of unified technical recommendations for research and development support (RDS) for all stages of the life cycle of the construction facilities of the I level of responsibility, which, according to Article 48.1 of the Town Planning Code, include:
- buildings and structures of specially dangerous and technically challenging facilities;
- constructions, in the design and construction of which fundamentally new design solutions and technologies are used that have not been tested in the practice of construction and operation;
- life support facilities for cities and settlements;
- tunnels, pipelines on the roads of the highest category or having a length of more than 500 m;
- construction facilities with a height of more than 100 meters;
- span structures of bridges with a span of more than 200 meters;
- large-span coatings of building objects with a span of more than 100 meters;
- construction facilities with console structures more than 20 meters;
- construction facilities with the underground penetration of more than 15 meters.

Analytical composition of documents is based on the provisions of the Federal Law - 384 TR "On the safety of buildings and structures". A special article outlines the requirements for the development of programs regulating the procedure for preparing and conducting work on research and development support for the state of elements of the construction facilities of the I level of responsibility aimed at ensuring safety and reliability at the operational period of the life cycle due to the quality of the stages of research and design, application of innovative materials, products and structures, advanced methods of control, etc. For facilities of the I level of responsibility, the economic component of the RDS program is to stand out in a separate article.

In the ISO 91.040.01 GOST 27751-2014 "Reliability of building structures and foundations. Basic Principles "presents general rules for computational models:
"cl.11 ...: 3. Calculation models of loads should include their intensity (value), place of application, direction and duration of action.

4. The computational models of the stress-strain state should include deterministic relationships that describe:
  - reaction of structures and their structural elements under dynamic and static loads;
  - conditions for the interaction of structural elements with each other and with the base.
5. Calculation models of resistance of building structures should include: - calculating models of local strength and stability, models of strength and stability of the element, models of the overall stability of the construction site; calculated models of instantaneous strength and models, taking into account the accumulation of damage in time; design models of strength and deformation of the base".

According to the methods presented in the standards: GOST 31937-2011. Buildings and constructions. Rules of inspection and monitoring of the technical condition; SP 20.13330.2016 "SNiP 2.01.07-85 Loads and Impacts", an assessment of the risk index in determining the safety of
construction processes is applied by comparing the actual value with the background level of safety introduced for the Russian Federation by the value $5 \times 10^{-6} [1, 3, 5, 6, 15]$.

The main condition is that the calculated value of the actual value should not exceed the base value.

The actual value of the risk is determined by the set of impacts presented in the regulations of the formula:

$$P = P(H)P(A/H)P(T/H)P(D/H)C, \quad (1)$$

where $P(H)$ - probability of emergency occurrence; $P(A/H)$ and $P(T/H)$ - probability of "meeting" the danger with the facility in space and time, respectively; $P(D/H)$ - probability of damage to this level; 
$C$ - relative damage (the ratio of the cost of damage to the value of the facility).

When assessing the risk indicator, the following levels are distinguished:

- acceptable ($P \leq 5 \times 10^{-6}$);
- unacceptable ($P \geq 5 \times 10^{-5}$), in this case urgent measures are required to low the indicator;
- adjustable ($5 \times 10^{-6} \geq P \leq 5 \times 10^{-5}$), adjustment of the indicator requires the consideration of social and economic aspects when determining the feasibility of planned activities.

In GOST R 22.1.12-2005 “Safety in emergencies. Structured system for monitoring and control of building / construction engineering equipment. General requirements”, the requirements for the implementation of a structured system for monitoring and managing engineering systems of buildings and structures, which should be built on the basis of engineering software tools, are designed to implement, on the appropriate categories of facilities, automatic monitoring of engineering support systems, the state of the foundation, building structures of buildings and structures, technological processes, engineering protection facilities and real-time transmission of information on threats and emergencies. Objects of control, threats of accidents, emergencies, are subsystems of life support and safety: heat supply; ventilation and air conditioning; water supply and sewerage; power supply; gas supply; engineering and technical complex of fire safety of the facility; lifting equipment; communication and alert system; security alarm, video surveillance, access control and monitoring systems, inspection means; detection systems for elevated levels of radiation, emergency chemically hazardous substances, biologically hazardous substances, a significant concentration of toxic and explosive concentrations of gas-air mixtures, etc.

The results of the conducted studies showed that the above requirements and regulations should be taken into account when developing: programs of research and development support of the construction facilities of the I level of responsibility; model of verification by level of responsibility; structured systems of monitoring and management of engineering systems the construction facilities of the I level of responsibility.

3. Development of the Construction objects of higher criticality rating verification model by the criticality rating

The offered model of Construction objects of higher criticality rating verification by the criticality rating assumes the following course of research, in particular, the establishment of options for selecting the accent component in a complex structured system with a functionally coordinated and interdependent element base, each of which, in the process of tracking feedback channels, transfers all other links of interaction into the category of marginal ones. In this study, the process approach of the development of the STS (Scientific and technical support) of Construction objects of higher criticality rating is based on the principle of anticipatory reflection of reality by the safety factor. To identify the safety level, factors should be established that allow the system to independently assess the situation, classify the level of abnormality and take appropriate measures to prevent it [1, 5, 6, 7, 15, 19].
Figure 1. Infographic modeling of a system with multiple-parameter dependencies of ensuring reliability and safety.

Consider the spatial unity of the system, where each component, in order to ensure a stable equilibrium, must be in the plane of only its inherent influence, exceeding the boundaries of which creates the risk of stability loss, with the onset of a different level of criticality, from the loss of a functional useful result to the violation of elemental safety.

Each implementation of the process change in the state of the system in time $S_{RM}(t)$ corresponds to a certain trajectory in the state space of $S_{RM}$. It should also be taken into account that $t$ is an irreversible nonnegative quantity the values of which can vary within $[0, T_p]$.

The equation of the system state by the safety factor in general form looks as:

$$S_{RM} = A\{X, q\},$$

where $A$ - is an operator that determines the nature of the dependence of the system state on internal processes occurring in it ($X$) and on external influences ($q$).

The process approach assumes a system with the extended structure of the components “Man - Object - Environment” and requires, when setting the reliability and safety parameters, their inclusion in the evaluation of the effectiveness of the main useful function, and the action principle (useful result of functionality) shows that the parametric changes of the unit element lead to the system change as a whole.

Using the variability law, the basic scheme can be mathematically conceived of as $[1, 11, 19]$:

$$R_t = R_{t0} e^{at},$$

where $R_t$ - current value of adopted parameter; $R_{t0}$ - conventional initial value of the parameter; $e$ – base of the natural logarithms; $a$ – invariable; $t$ – time, measured from the moment corresponding to $R_{t0}$. 
Considering Construction objects of higher criticality rating as not a safe system with various factors of influence on failure risk in a random segment of the operational period, the concept of “time-lag” is introduced. This concept is mathematically described by the tools of Boolean mathematics as a monotone function: 
\[ y_i(X_m) = y(x_1, ..., x_{i-1}, 1, x_{i+1}, ..., x_m). \]

Characteristics of variability are inherent in logical functions, arguments of which are Boolean variables \( x_1 \). The variability of the elemental state is represented as “zero”, “physical” (real) and “unit” function, having a general form 
\[ f(X_1, y). \]

Interaction on the segment of the operational period will take dependence 
\[ f(X_1, y) \subseteq [y(X_m)] \subseteq [y_1(X_m)]. \]

Using Boolean tools, we specify the safety parameter via the conjunction operator, and via the disjunction operator – the risk parameter. The inversion operator shows the comparability of danger – safety levels: \( E \leftrightarrow 1 \subseteq P \leftrightarrow 0 \).

The impact factor of the onset of a dangerous situation can be established by introducing a conventional indicator reflecting the “contribution of the event” to safety
\[ B_i = P \xi_i, \quad (4) \]
where \( \xi_i = P(\Delta_i q_i(X_m)) \) – is the partial derivative of the probability of the onset of system dangerous state.
\[ q_i = \sum_{i=1}^{r} 2^{-(r+1)} - \sum_{j=1}^{i} 2^{-(i-1)} \]
the level of deviation of the probability state vector of the “risk-safety” system for the elemental base of the Construction objects of higher criticality rating, where \( e \) is the number; \( r_i \) is rank.

Giving a characterization of the level of the danger manifestation it is necessary to pass from the qualitative characteristic to a quantitative analogue.

According to the performance standard, the modal analysis establishes a consistent effect of the design elements of the Construction objects of higher criticality rating on the safety of the object as a whole, with the following dependence:
- the safety parameter for a unit element, for example, the basis of Construction objects of higher criticality rating, is laid throughout the resource period:
  - with a risk index of \( 1 \times 10^2 \) and allows a combination of a sequential influence of three elements;
  - with a risk index of \( 1 \times 10^3 \) and allows a combination of the sequential influence of two elements;
  - with a risk indicator of \( 1 \times 10^6 \) and allows only a combination of parallel influence of elements.

With similar values of the risk indicator with the restriction of the actual value to a standardized value of \( 5 \times 10^{-6} \).

For a system with an extended structure of the components “Man - Object - Environment”, the most significant risk is the probable damage to a man, it is logical to classify the script in the category of high risk, which will change the person’s social opportunity to realize themselves, i. e. harm to health, which can’t be morally and / or physically compensated.

Empirically, the indicator of the law value of dangerous manifestation level was established and a proportionality coefficient having the dimension of the damaging factor is proved.

It seems correct to move from categorizing the danger level of “death” to the notion of “loss of social level – alive, but with physical or moral limitations” with a discreteness of \( 1 \times 1000 \).

It should be noted that the indicator of the shift in the average level of dangerous manifestation plays an important role
\[ b = 1 - \eta \ln P, \quad (5) \]
where \( \eta \) - is a shift factor; \( P \) – probability of a system failure situation with a risk of fatal consequence.
By varying the value of the weight limit (upper – lower limits), it is possible to set the shift factor, and by making the infogram, visually evaluate the consequences of lowering the limits, which in turn will allow establishing the limits of the weighting of the system elements as a whole.

A similar algorithm can be used to establish environmental risk, with the introduction of dangerous level criteria. Accordingly, it becomes possible to establish safety conditions by various criteria.

The modified methods assumes the construction of tables containing the limits of parameters change with establishing the level of dangerous manifestation and calculation of the valueso of the corresponding damaging factors for the system with the expanded structure of the components “Man – Object – Environment”.

It is proposed to apply the developed methodology as a supplement to the Construction objects of higher criticality rating verification model by the level of responsibility in setting the regulatory requirements.

4. Discussion
Suggested approach allows performing similar calculations based on the results of taking into account the actual state of the elements of Construction objects of higher criticality rating at any period of operation, fixing the current performance indicators inherent in the computational model, which will allow for a real-time quantitative concept of the reliability and safety level, which supplements the results obtained in the studies of other scientists [6, 12, 14, 19, 20].

The significance of the problem of ensuring reliability and safety in the operation of Construction objects of higher criticality rating, taking into account the socio-eco-economic and technical paradigms of different time lags in scientific communities at large, has not yet received due attention; additional techniques are required that can be adapted to the specifics of the region in a long time interval and a flexible modification system concerning new technologies and technical support tools [20, 21, 22, 23, 24, 26, 27].

At the same time, the data of statistical data on the facts of abnormal situations show the significance of the work performed [4, 15, 16, 18].

The authors consider that the interdisciplinary, system-process approach of the conducted research provide the basis for the development of programs of scientific and technical support, verification modeling of the criticality rating and monitoring structure systems of full life cycle of highly dangerous, technically complicated and unique objects and will be an optimal supplement to the regulatory and technically regulated set of construction rules.

5. Conclusions
1. The incoordination hypothesis of the existing standard methodology of construction procedures with real operational periods of facilities and structures in terms of a long time lag is proved.
2. It was found out that there are no unified technical recommendations on scientific and technical support and monitoring of the full life cycle of highly dangerous, technically complex and unique objects.
3. A structural model of scientific and technical support for the construction of highly dangerous, technically complex and unique objects was made.
4. The possibility of applying the combinatorics law to the reliability and safety assessment of Construction objects of higher criticality rating is proved as to a complex structured system with a functionally consistent and interdependent element base of a given finite set.
5. The proposed scheme is realized using the example of calculation with the Pascal triangle of the binomial coefficient.
6. The process approach of STS of Construction objects of higher criticality rating development is used based on the principle of ahead reflection of reality by the safety parameter, an infographic model of the system with multiparameter characteristics of life cycle stages was created.
7. Empirically, the indicator of the minimum weight of the dangerous level manifestation is established and the proportionality coefficient having the dimension of the damaging factor is approved.

8. It is proposed to apply the developed methodology as an addition to the development of scientific and technical support programs, a model for verification by the criticality rating and structured monitoring systems for the full life cycle of highly dangerous, technically complex and unique objects.

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References
[1] Bogomolov A A, Bunin M V and Sevryugina N S 2009 Structure and semantics of a variational optimization of transport machines and technological processes in General systems theory: a monograph (Belgorod: Publishing house BGTU) P 83
[2] Goropashnaya A V 2009 The assessment of the importance of non-monotonic arguments of Boolean functions in logical-probabilistic safety analysis of complex technical systems Ser 10 vol 1 (Herald of St. Petersburg University), pp 19 – 32
[3] Dontsova T V and Semenova E A 2012 Achieving ecologically sustainable development of the planet as a social process part of the concept of biosphere compatibility and the ecological footprint rel 7 (Scientific problems of humanitarian researches of Pyatigorsk) pp 176-80
[4] Kapyrin P D and Romanova C E 2010 Analysis of current state of the building materials industry and the factors contributing to the development of production No. 4-1 (Vestnik MGSU) pp165-70
[5] Polyakov Yu I 2008 Theory of the manifestation of danger: the main objectives of the strategy of technical regulation of safety of technical regulation No. 2 (Bulletin of the scientific center) pp154 – 64
[6] Telichenko V I, Zavalishin S I and Khlystunov M S 2005 Global risks and new threats to the safety of the responsible construction sites of the megalopolis (Collection of reports of the thematic scientific and practical conference "The City Building Complex and the Safety of Life Support for Citizens" (Moscow: MGSU) pp 211-18
[7] Shcherbina G F 2010 Theory and practice of implementing the process approach in the activity of the construction holding No. 12 (Issues of economics and law) pp 174-179
[8] Korol E, Kagan P, Babarabanova T and Bunkina I 2016 Description of technological processes in construction using formal language T 11 No. 3 (International Journal of Applied Engineering Research) pp 1691-93
[9] Dontsov D G and Yushkova N G 2017 Principles of sustainable development of the territory and priorities of architectural and urban construction activity (AIP Conference Proceedings Proceedings of the III International Young Researchers Conference) p 050011
[10] Gusakov E A 2004 The systems engineering organization life cycle of the construction object: a monograph (Moscow: Fund "New Millennium") P 256
[11] Verigin Yu A and Tolstenev S V 2007 Synergetic foundations of processes and technologies: monograph (Barnaul: Izd. AltSTU) P 158
[12] Lebedev V M and Volkov A A 2010 Organizational and technological reliability of construction using systemquants of processes and facilities No. 3 (Bulletin of the Belgorod State Technological University named after VG Shukhov) pp 177-82
[13] Grechishchev S E, Magomedgadzhieva M A, and Dmitrieva S P 2005 Special features of frost heave of a buried chilled gas pipeline (Proceedings of the International Offshore and Polar Engineering Conference ISOPE 2005)
[14] Bayburin A X and Melchakov A P 2017 *Technical regulation of safety of buildings and constructions on the basis of assessment of risk of accident* No. 11 (Architecture, town planning and design) pp 3-10 (http://hdl.handle.net/10995/39798)

[15] Melchakov A P and Cheboksarov D V 2009 *Forecast, assessment and regulation of risk of accident of buildings and constructions: theory, methodology and engineering applications: monograph* (Chelyabinsk: Publishing house YuUrGU) P 113

[16] Nikonov N N, Melchakov A P and Rudin V N 2013 *Safety of constructions* No. 3 and No. 4 (Industrial and civil engineering) P 36

[17] Dontsov D G 2014 *Problem of territorial development and reference points of urban policy in documents of regional planning* No. 38 (The bulletin of the Volgograd state architectural and construction Construction Series university and architecture) pp 196-209

[18] Smolyar I M 2000 *Town planning and society* No. 2 (Architecture and construction of Moscow) pp 13-17

[19] Sevryugina N C 2012 *Theory of formation of technical safety of full life cycle of transport and technological machines: monograph* (Belgorod: BGTU publishing house) P 179

[20] Makhutov N A, Gadenin M M, Cherniavskaya O F, Cherniavsky A O and Evropin S V 2009 *The Process of low cycle deformation structures of nuclear power plants and methods of their calculation* T 107 No. 3 (Nuclear energy) pp 136-42

[21] Abramov V V, Racunov Yu P and Kapyrin P D 2014 *On the mechanical and physico-chemical phenomena at the interface of dissimilar solids with thermal effects* (In the book: knowledge Intensive technologies and innovations. Jubilee international scientific-practical conference dedicated to the 60th anniversary of Belgorod state technological University them. V. G. Shukhov, XXI scientific readings) pp 189-93

[22] Abramov V V, Petukhov S V, Ivanyugin V M, Rakunov Yu P and Kapyrin P D 2016 *Electronic vision system of the mekhatronny intelligent robot for finishing of wall panels* T 77 No. 3 (Construction mechanization) pp 24-33

[23] Stupakov A A, Kapyrin P D, Lelikov G D, Semyonov P A and Vasilenko B B 2015 *Benches for researches of individual protection equipment from falling of the person about heights* No. 8 (MGSU Bulletin) C 130-39

[24] Telichenko V I, Shuteev S A and Yusupaliyev U 2000 *Intelligent instrument of new generation for determination of deformation of buildings and engineering constructions* No. 4 (Application-oriented physics) pp 415-28

[25] Korol E A and Kagan P B 2015 *Management systems of urban planning* T 11 vol 3 (International Journal of Applied Engineering Research) pp 43456-60

[26] Telichenko V and Dorogan I 2016 *Radiation safety in designing of health care facilities* T 11 vol 3 (International Journal of Applied Engineering Research) pp 1649-52

[27] Zhabin AB, Fomichev A D, Naumov Ju N and Solovyh D Ja 2016 *Results of studies of shaft boring machine operation in vertical shaft construction at upper kama potash deposit* vol 1 (25) (Eurasian Mining) pp 29-32