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Digital transformation of standardization and quality control in construction production based on the implementation of the registry principle of managing the requirements of regulatory and technical documentation

Ensuring the quality of construction and installation work is traditionally a priority task of the construction industry, and today it is becoming the basis for the formation of criteria for the effectiveness of transformation processes in the conditions of the formation of the digital economy. The article is devoted to the search for ways to develop methodological tools for digital transformation of standardization and control of construction and installation works for a wide range of construction participants. Large-scale application of information modelling technologies and digital models at all stages of the life cycle of capital construction projects requires radical changes in the organization and development of the industry regulatory and technical framework for quality assurance. In many ways, improving the quality of construction and installation work depends on the loyalty of designers and builders to the registry principle of technical regulation. The author focused on the criteria for improving the quality of technological processes in construction. To achieve this goal, in the article the author proposes to consider the concept of formation and application of registers of regulatory requirements (RRR), designed to change the approach to work with the regulatory document, including in the assessment of conformity of the presented construction and installation works (CIW) carried out in accordance with this standard. The applied RRR assume a different structure of information, where the key element is the requirement. The requirement structure contains numerical parameters generated for specific processes.

The concept assumes integration of the registers of requirements with the building information model, formation of a request and application of data uploaded from the model on the list of works, their volumes, organizational and technological links between the works, etc. The register, with formulas for conformity assessment linked to it, is considered as a tool for automating operational control. When the requirements of work acceptance are met, data are generated to form digital performance documentation and fill in the digital performance model. The concept is being developed as one of the directions of the scientific and educational programme of activities implemented in the Scientific and Educational Center "Digital Construction and Operation" of Moscow State University of Civil Engineering with a partner — JSC "Codex".

Keywords: *standardization of construction technologies, digital tools for construction quality control, construction and installation works, register of regulatory documents, digital register of regulatory and technical requirements, building information model, regulatory and technical requirements*

DEVELOPMENT OF THE REGISTRY PRINCIPLE

The article is a continuation of a series of studies on the role of the registry principle and parametric rationing in the digital transformation of the construction industry.

Introduction and implementation of the registry principle of maintaining technical requirements in construction is one of the tasks of improving the system of technical regulation in construction. In accordance with the Development Strategy of the construction industry and housing and communal services of the Russian Federation for the period up to 2030 with a forecast up to 2035: the registry principle of the development of technical requirements is the principle of development of technical requirements, assuming the possibility of their practical implementation only after the inclusion of such requirements in the relevant register [1]. At the same time, it is assumed that the principle will be ensured by forming an integral system of regulatory documents that establishes uniform mandatory requirements at all stages of the life cycle of a capital construction object (CCO). Currently, regulatory

acts include linking the implementation of the registry principle and the creation of a system for managing safety and quality requirements of the CCO, based on a digital register of requirements in the construction industry. With this in mind, the register of requirements becomes a state information resource designed to provide interested parties with information about the requirements to be applied during the examination, design, construction, reconstruction, operation and demolition of capital construction facilities [2]. It should be noted that the formation and maintenance of the register of requirements in the field of engineering surveys, design, construction and demolition are carried out in Russian in electronic form using the State information system for urban planning activities (SISUPA) system based on Stroykompleks.RF. The requirements included in the register are placed in XML format. For state authorities, local self-government bodies, legal entities and individuals, the requirements included in the register of requirements in the field of engineering surveys, design, construction and demolition become open for review [3]. The most probable scenario is considered to be when the formation of registries will technically take

place in 3 stages: analysis of documents including requirements, detection of requirements in the document and systematization of requirements in the relevant registries.

At the same time, checking the relevance of the requirement is a more resource-intensive process than checking the relevance of the standard [4]. There are several reasons for this:

- document may contain a different number of regulatory and technical requirements;
- same document may contain requirements for different jobs or processes;
- most documents include both mandatory and recommended requirements;
- current document may contain modified requirements;
- document may continue to be valid, but the requirements contained in it may be canceled or supplemented with new requirements;
- multiple documents may contain cross-requirements.

The proposed concept, focused on ensuring the formation of an integral system of regulatory documents that establish uniform mandatory requirements at all stages of the life cycle of the CCO, involves the development by the user of a register of documents containing requirements and further work with requirements, changing to an algorithm for the direct formation by the user of a register of requirements [5]. Moreover, in terms of integration with the digital information model, the registry becomes part of it and receives the parameters of a digital tool.

INTEGRATION OF DIGITAL REGISTERS OF REGULATORY REQUIREMENTS AND BUILDING INFORMATION MODELS

The concept under consideration assumes the initial formation of a register of requirements in the preparation of Technical specifications for the development of design and estimate documentation, including organizational and technological documentation. The formed requirements in relation to the corresponding types of elements, structures, materials and equipment used are integrated into the information model along with other parameters. When forming the structure of the library components of the information model,

the principle of highlighting aspects of the system is applied [6]. According to this principle, the registers of requirements can be included in the model as functional aspects or product aspects. After the transfer of the project information model to the construction site, this makes it possible to obtain from the model, in addition to the names of works, their volumes, materials used, to obtain current requirements for the production of works, requirements for which structures, requirements for elements of engineering systems. The same requirements define quantitative and qualitative criteria when carrying out construction control of the technical customer, as well as when the contractor submits completed works or finished structures for compliance verification. After acceptance of the work, the requirements in the structure of the information model, in turn, become the basis for the formation of operational requirements for structures, elements, and engineering systems. At the stage of building operation, the registers will in turn become the basis of operational service, maintenance, monitoring, current and capital repairs, reconstruction and demolition [7]. Fig. 1 shows a block diagram of the implementation of the concept.

The described concept, which in its structure provides for application of the registry principle of the formation of regulatory requirements, using Russian software and information reference systems, allows us to solve the following tasks:

- implementation of automatic unloading from the information model of lists of construction and installation works, their volumes, with the possibility of visual analysis of organizational and technological links between the works, which allows to provide automation of development of organizational and technological documentation: work production projects (WPP) and technological maps (TM);
- formation of a register of regulatory requirements for the quality of construction and installation works, with formulas attached to it to assess the compliance of the results of construction and installation works with the requirements of national standards, design, working and organizational and technological documentation, which allows to implement automation tools for construction and operational control and generate data for filling the digital executive model.

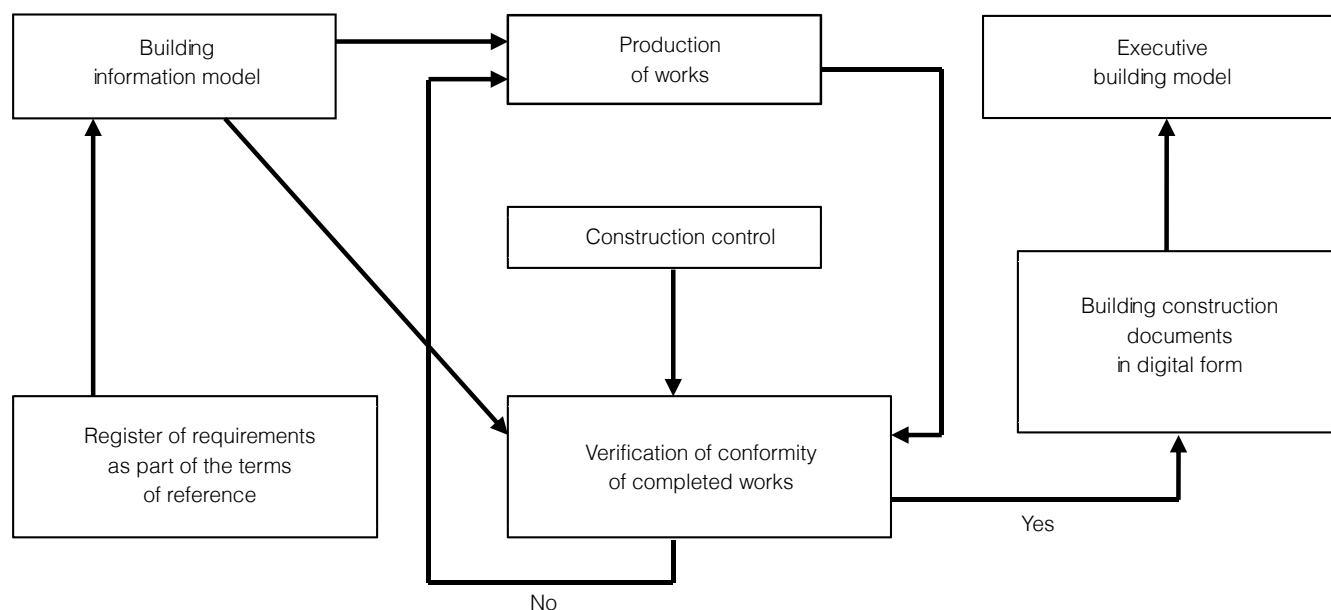


Fig. 1. Block diagram of the concept implementation

► In addition to the basic requirements, the register may include requirements related to the work being carried out and required by applicable regulations. These can be:

- requirements for ensuring technological modes of work, established by organizational and technological documentation;
- labour protection requirements when performing the relevant production operations;
- requirements to ensure compliance of quality indicators of operations and their results with standardization documents [8].

IMPACT OF THE REGISTER OF REQUIREMENTS ON THE QUALITY OF CIW

Introduction and implementation of the registry principle of maintaining technical requirements in construction is one of the tasks of improving the system of technical regulation in construction. Ensuring automatic updating of the registry and linking a specific requirement to the relevant production processes is a task of increased complexity. It should be noted that at the moment there are no ready-made registers of mandatory and recommended requirements for construction.

The register of requirements formed by the customer and integrated into the building information model can be applied at one or several stages of the object life cycle, for example, during the examination, preparation of design and estimate documentation, implementation of construction or reconstruction, performance of operational activities or demolition. The methodological basis for the application of data from information models at different stages of the object life cycle, the formation of requirements for them is implemented within the framework of a set of standards of a Unified Information Modelling System [9]. Accordingly, as part of the terms

of reference for the tender documentation or for the contract, the register of requirements can be opened for review or already applied by prospectors, designers, surveyors, contractors, operating organizations. The concept assumes that the registers, together with the requirements, will contain the calculated parameters of the requirements, which in turn determine the calculated parameters of works being carried out. During the period of works, ensuring compliance of the work performed with the project documentation and the requirements of regulatory and technical documentation is carried out by means of current and acceptance control. The result of compliance is a qualitatively completed and commissioned object. At the stage of conformity assessment of the submitted works, controlling precisely the calculated parameters of the work, it will be possible to control the specified level of quality of works, the structures and products used. The concept contributes to the formation of a systematic approach to the work with the registers of requirements through the detection, documentation, tracking of requirements for the created constructions and conducted production processes. It should be noted that in this case, the work with the requirements is carried out without the need for constant work with the entire documents.

From the above, the necessity of solving the problem of requirements management as a task of searching for an individually configured or typical, but in any case balanced set of parameters by which it is possible to determine the actual level of work performed. It can be argued that the requirements management mechanisms will become mechanisms for ensuring the quality of work.

APPROBATION OF THE CONCEPT

As part of the testing of the concept, we will consider the integration of the register of requirements for finishing works and data that make up part of the information model of a residential building.

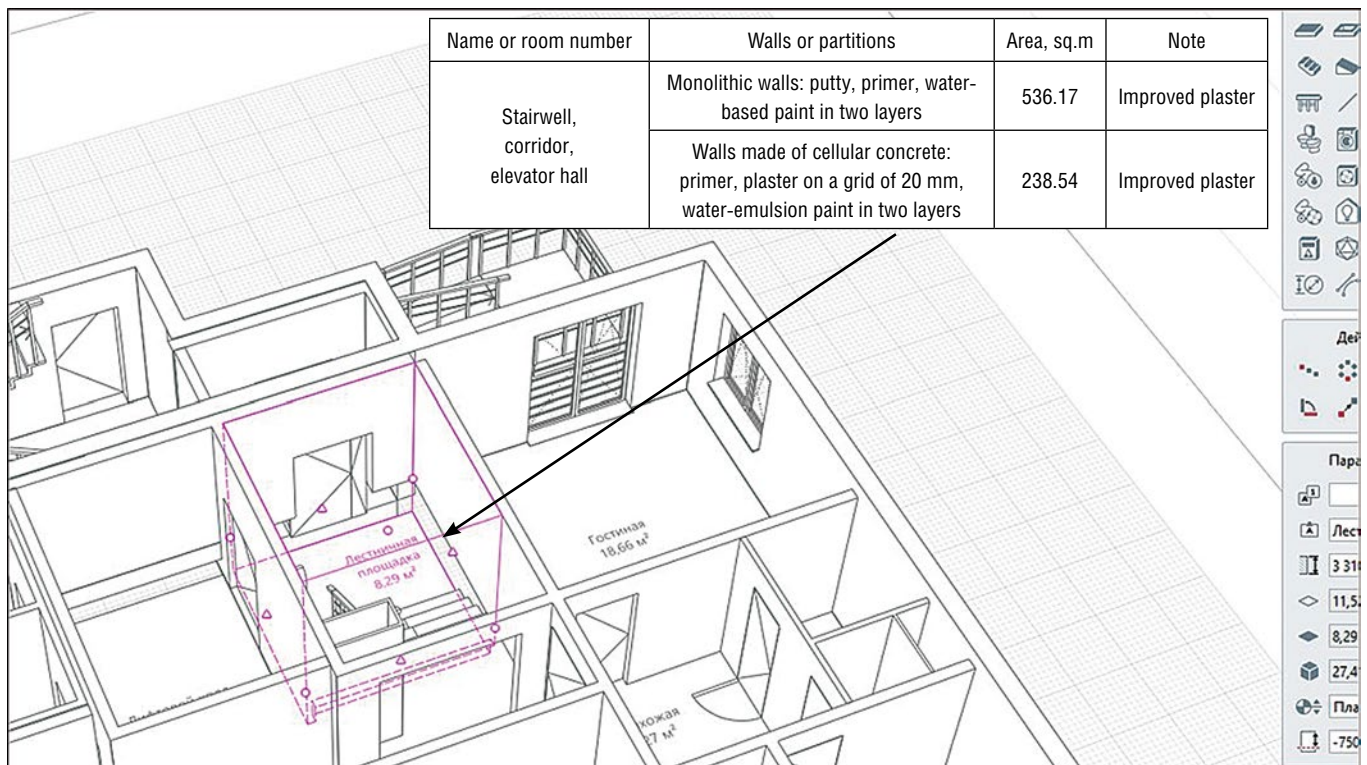


Fig. 2. Data on interior decoration from the building information model

The object of testing will be an 88-apartment residential building in Kaliningrad, Levitan str., 10. The project documentation for the object is included in the GIS of the Unified State Register of Legal Entities and is standard. The model was created in Renga automated building design system (version 5.5). To form a register of requirements for finishing works, we use "Techexpert SMART: design" — a professional reference system containing services for the introduction and use of information modelling technologies (IMT), as well as regulatory documents, reference and consulting information necessary in the work of the designer. Working on the creation of a digital register of regulatory and technical requirements in the "Techexpert" system, it is possible to work with regulatory documents as with "data containers" [10]. When working with the building information model, we will need the materials of the sections "Spatial planning and design solutions" and "Construction organization project". It is possible to use attracting data from a larger number of model elements. After all, the gradual accumulation in digital format of more and more information about the object in the process of design and construction makes it possible to significantly increase the efficiency of operation of buildings and structures in the future [11].

At the next stage, from the information model of the building, all the data on the decoration of the premises necessary for compiling a statement of the scope of work are unloaded. To simplify, the example considers only one room – the stairwell of the floor. Fig. 2 shows a part of the statement of the scope of work on finishing, with data uploaded from the information model of the building.

The task of forming a register of requirements with the use of modern professional reference systems (for example, "Techexpert" system) for the construction industry is gradually being transformed into a system IT solution that allows you to fully automate the requirements management process and select requirements according to specified parameters. The article presents an algorithm for working with the "Techexpert" system to create a register of requirements for finishing works on the stairwell of a residential building. However, the algorithm is built in such a way that it can be shifted to other, more complex tasks. When working with the standard, mandatory, recommended and reference requirements are

Parameter	Standard value, mm	Real value, mm	Compliance with standards
Vertical deviation:			
by 1 m	2	1	yes
for the entire height of the room	10	11	no
Horizontal deviation by 1 m	3		
Deviation of window and door slopes from the vertical:			
on an area of 4 m ² by 1 m	4	3	yes
for the entire element	10	8	yes
Deviation of window and door slopes from the horizontal:			
on an area of 4 m ² by 1 m	4	5	no
for the entire element	10	11	no
Deviation of the slope width from the project	3	1	yes

Fig. 3. Fragment of the desktop when comparing requirements values

established in separate positions. The formation of the register of requirements in the concept includes the following stages: selection of documents; detection of requirements from different documents; consolidation of requirements in the register. During the production of CIW, respectively, the control of changes in requirements, the analysis of changes, as well as the systematization of information on the compliance of the actual parameters of the work performed with the standards are carried out. The application of the formed register of requirements, in our example, in the conditions of the use of the "Techexpert" system and documents in the "xlsx" format, will be presented as follows: automatic binding to the standard with the possibility of automatic updating; manual binding of each parameter to the appropriate place within the standard; verification of the status of the requirement (comparison of standards, comparison of editions); automatic calculation compliance of the performed works with the standards. In previous publications, the issues of solving the main tasks of allocating the registry structure with their connection to the system of automated control of the relevance of regulatory documents in the formation and work with registries have already been disclosed [12]. The main block of work on the register of requirements is undoubtedly the process of comparing the normative values of requirements with the values actually obtained. The registry considered in the example includes requirements for all layers of the walls of the stairwell of the building: improved plaster, primer coating, and painting.

By applying the register of requirements, the building control or supervision officer receives a universal tool in the form of an automated quality control table, the template of which will be updated in real time to ensure compliance with current editions of regulatory and technical documentation. This allows you to analyze information about the quality of requirements and procedures. In addition, many control measures at the federal level will soon receive strict digital binding to norms and requirements [13]. In addition to directly automated data updates, the "xlsx" format allows you to automate the analysis of regulatory and real parameters, automate and configure the output of final data in a convenient form. The task of ensuring the relevance of the funds of regulatory documents was taken over by the "Techexpert" system, and the further level of automation of the technological process depends on the skills of a particular employee of the construction control or supervision service [14].

Summing up, here are the main effects of the application of the integration of registers of requirements and information models of the building, directly or indirectly affecting the quality of CIW:

- reducing labour costs, and therefore reducing the risk of errors when working with regulatory standards;
- the ability to automate work with requirements;
- performing calculations in standard programmes with reference to current databases of reference systems;
- the ability to automate individual processes during operational control;
- the possibility of using registers in the formation of digital executive documentation.

CONCLUSIONS

Reproduction of the concept on a sufficient list of CIWs based on the professional and loyal attitude of engineering and technical workers of the construction industry to the use of project documentation in the form of a digital information model will accelerate the digital transformation of construction production and control measures. The creation of such conditions is primarily facilitated by

▶ providing a wide range of engineering and technical workers in construction and operation with simple and reliable tools for solving everyday practical problems of ensuring the quality of construction and installation work. In the future, it can be transferred to more complex tasks, where you need to take into account a whole range of requirements and parameters. Moreover, the development of the proposed algorithm as an integrator technology and its application by enterprises and organizations of the construction industry will help ensure their competitiveness by improving the quality of work at all stages of the life cycle and creating conditions for meeting deadlines for their implementation.

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Цифровая трансформация стандартизации и контроля качества в строительном производстве на основе реализации реестрового принципа управления требованиями нормативно-технической документации

Обеспечение качества выполнения строительно-монтажных работ традиционно является приоритетной задачей строительной отрасли, а сегодня в условиях становления цифровой экономики выступает основной формированием критериев эффективности трансформационных процессов. Статья посвящена поиску путей развития методического инструментария цифровой трансформации стандартизации и контроля выполнения строительно-монтажных работ для широкого круга участников строительства. Масштабное применение технологий информационного моделирования и цифровых моделей на всех этапах жизненного цикла объектов капитального строительства, требует радикальных изменений в организации и развитии отраслевой нормативно-технической базы обеспечения качества. Во многом повышение качества строительно-монтажных работ зависит от лояльности проектировщиков и строителей к реестровому принципу технического регулирования. Автор ориентировался на критерии повышения качества проработки технологических процессов в строительстве. Для достижения цели автор предлагает в статье к рассмотрению концепцию формирования и применения реестров нормативных требований (РНТ), призванных изменить подход к работе с нормативным документом, в том числе при оценке качества предъявляемых строительно-монтажных работ (СМР), проводимых в соответствии с данным нормативом. Применяемые РНТ предполагают иную структуру информации, где ключевым

элементом является именно требование. Структура требования содержит в себе числовые параметры, формируемые для конкретных процессов.

Концепция предполагает интеграцию реестров требований с информационной моделью здания, формирование запроса и применение выгружаемых из модели данных по перечню работ, их объемам, организационно-технологическим связям между работами и др. Реестр, с привязанными к нему формулами для оценки соответствия, рассматривается как инструмент автоматизации операционного контроля. При удовлетворении требований приемки работ формируются данные для создания цифровой исполнительной документации и наполнения цифровой исполнительной модели. Концепция развивается как одно из направлений научно-образовательной программы деятельности, реализуемой в Научно-образовательном центре «Цифровое строительство и эксплуатация» (НОЦ ЦСЭ) НИУ МГСУ в сотрудничестве с партнером АО «Кодекс».

Ключевые слова: стандартизация строительных технологий, цифровые инструменты строительного контроля качества СМР, реестр нормативных документов, цифровой реестр нормативно-технических требований, информационная модель здания, нормативно-технические требования

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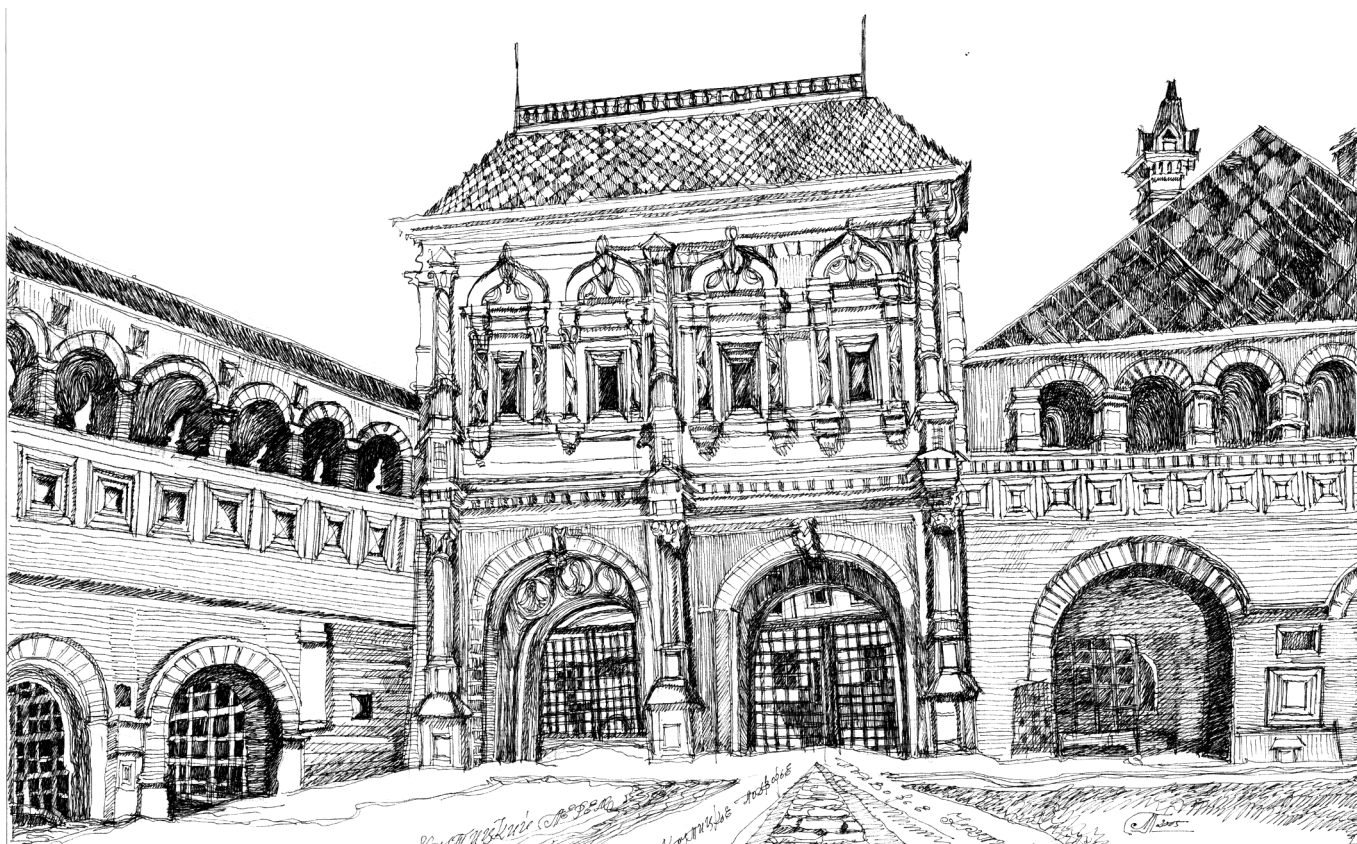
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