State examination of BIM-model on the basis of object technological dependencies model

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Abstract. It is important to check the projects created on the basis of BIM. In this case, an automated process of checking and evaluating the quality of the BIM-model is necessary, for example, for express checking in the state expertise. At the same time, it is necessary to take into account the technological and organizational features of construction and installation works. This issue is especially important and relevant for facilities that are dangerous and technologically complex (for instance, stadiums, high-rise buildings, hydroelectric power stations, bridges). In the article the authors propose to approach the examination of the state expertise of the projects of these objects from the position of the model of object technological dependencies. The key factor of this model is a description of the technology of the facility construction, which displays the technological interrelation of the works, their quantification and the definition of the time domain of these works. The model includes technological dependencies "no earlier than the beginning" and "no earlier than the end", as well as the parameters of the maximum saturation of the workforce. The fundamental difference between this model and those currently in use is the availability of a time domain for each work.

1. Introduction
In April 2017 a significant event occurred for the Russian regulatory and legal framework in the field of information modeling (BIM) – a road map – was signed to introduce information modeling technologies at all stages of the life cycle of the capital construction site. Its development began with an initiative working group in 2012 and for six years has been repeatedly criticized by the professional community. It is worth noting that a year after approval of the BIM road map in Russia, the criticism of the document does not abate, and the timing of some events is not met.

Within the framework of the road map, national standards of information modeling have been created and will continue to appear for all stages of the "life cycle" of capital construction objects, normative and technical documentation and estimated standards have been brought into line with the classifier of construction resources. The system of normative and technical documents in the field of BIM in Russia in total will include 15 national standards (GOST R) and 10 sets of rules. For two years in the BIM area, 7 GOSTs and 4 sets of rules were created and approved for practical application, the latter entered into force on June 16, 2018. It should be noted that 3 of the existing set of rules are of a general nature, and JV 333.1325800.2017 "Information modeling in construction. Rules for the formation of the information model of objects at different stages of the life cycle "are not designed to work with particularly dangerous, technically complex and unique objects, since they extend to the processes of information modeling in the design, construction and operation of objects of mass
construction [1,2]. It is planned to finish the development and approval of the remaining documents until the end of 2020.

Design organizations still refer to the creation of BIM-models solely as an operation, which reduces the time to prepare the model and check the collisions that arise in the model. At the same time, it is noted that state expertise of BIM-models is not needed. But for an expert who evaluates the project, first of all, the information that he can get from the project is important [3,4]. In many cases, the time for review of project documentation increases due to the lack of information in the documentation and the inconvenience of the documentation presented (even if it is presented in electronic form!). This is the reason for many comments that arise from experts, which increases the time for preparing comments, communicating with the designers. In this regard, information modeling provides experts with more opportunities to verify and document documentation. Project organizations still relate to the creation of BIM-models solely as an operation, which reduces the time to prepare the model and check the collisions that arise in the model.

At the same time, it is important for the project documentation expertise to integrate building codes into the BIM-model, which will allow to extract the necessary data from the model. For example, in Singapore, the given task is solved by using RASE (requirements, applicability, selection, exception): the standard for document processing [5-7]. This algorithm specifies the logical structure of the document, which is present in the BIM-model. Also important is the possibility of automated verification of the technological and organizational sequence of works in accordance with the requirements of technological maps of work performance, construction norms for resource consumption. It should be possible to work together with the model simultaneously, that is, several experts should be able to view data and make comments on the model.

2. Application BIM in the state expertise of construction projects

The state expertise of design documentation and (or) the results of engineering surveys is mandatory for certain types of capital objects, including particularly dangerous and technically complex facilities:

- facilities that use atomic energy;
- hydraulic engineering structures;
- hazardous industrial facilities (for example, hazardous waste processing);
- unique objects (for example, skyscrapers);
- roads and other.

Verifying the reliability of the design of the implementation of technological dependencies on similar facilities is a complex task that goes beyond the documents to be submitted for examination [8,9].

For the design and construction of such facilities, the use of information building models (BIM) is currently required and necessary [10-14].

The first "pilot" region of Russia, in which since 2019 the state expertise will be transferred to BIM, will be Moscow. The corresponding document was signed in October 2017. During 2018, it is expected to create a regulatory framework for the use of this technology, training existing staff, as well as checking the functioning of BIM on "pilot" projects.

In order to avoid the occurrence of accidents with severe consequences and loss of life, it is necessary to emphasize the importance of conducting state expertise of projects carried out in the form of an information model for technically complex and especially dangerous objects of national importance. The project documentation of the Vostochny launch site received positive results from the examination, and the stages of the construction of the high-speed Moscow-Kazan-Yekaterinburg highway section were approved. The projects that were significant for the state were implemented in the form of an information model based on internal BIM standards of the project developers [15,16]. Thus, the state solves the problem of increasing the efficiency of construction, preserving the quality and the possibility of launching the project on time, while reducing risks and investments.

Since January 1, 2018, changes have come into force regarding the procedure for passing attestation for the right to prepare expert opinions on design documentation and (or) engineering
surveys. Since that moment, experts are required to improve their qualifications on the profile at least once every 3 years (earlier this period was 1 time in 5 years). In addition, the certification procedure itself became more complicated: the number of correct answers in questions increased, the time of the examination was shortened, and the percentage of correct answers for obtaining a certificate increased. For experts wishing to obtain a qualification certificate or to extend the term of the existing qualification certificate for the right to prepare expert opinions on the design documentation for the construction of highly dangerous, technically complex and unique facilities, facilities for which state expertise is conducted by federal executive authorities and organizations authorized to conduct it, facilities, financing of which is carried out at the expense of the budgets of the budget system of the Russian Federation, the two-stage procedure for the examination. Thus, the state is trying to solve the problem of low skill level of the cadres, as well as expanding the area of knowledge of specialists of narrow profiles. According to some estimates, at first only 30-40% of current experts will be able to pass the re-certification.

3. **Object technology dependency model for the purposes of state examination of complex objects**

One of the plans, which is checked by the state. expertise, is a calendar plan. The calendar plan is the basis for solving many problems [17, 18]. The calendar plan is an unstable model for the construction of an object, as it is influenced by a large number of external and internal factors. The calendar plan must be consistent with the organizational and technological models of the construction of the facility. In turn, organizational and technological models are stable and should not change depending on changes in different conditions.

In order to coordinate the calendar plan and organizational and technological models, the authors propose to use the object technology dependency model (OTDM) [19, 20], which should be included in mandatory documents that require verification by the state. expertise. Such a model, describing the technological interrelationships of works and their quantitative assessments at the beginning and end of the work, was developed and presented on Fig. 1. It is important that when calculating quantitative estimates, there are no organizational decisions. This increases the stability of the model for solving the tasks of planning construction works and organization of construction production.

Verification of this model by experts should give an answer to the question of the feasibility of performing construction and installation works within the specified timeframes with observance of the technology of production of works, the possibility of combining works, safety engineering.

The construction of the OTDM is possible when using the data of the BIM-model, which is mandatory applied for checking state. expertise.

The construction of the OTDM can be accelerated if BIM-technologies are used. In this case, many errors that are possible in the case of constructing the OTDM in manual mode are eliminated:

- inclusion of additional attributes in the BIM-model (minimum volume at the beginning and at the end, as well as technological connection of the work) allows the construction of the OTDM in a semi-automatic mode;
- automatic data changes in case of model rebuilding;
- addressing the use of single or aggregated work.

In the event that an inspection of the OTDM is carried out, the examination of the project will consist of the following stages:

Stage 1. Checking the distribution of work volumes by period (the ability to perform these volumes in the specified period).

Stage 2. Conducting audit of intensity, shifts, duration of works, beginning and completion of each construction process within the time domain, combining production of technologically related works, etc.
4. Conclusion

Despite the fact that earlier it was said about the transition from the year 2018 to the mandatory use of BIM-models for the objects, the construction of which is carried out at the expense of budgetary funds, at the moment no specific time has been set. In the opinion of Igor Manylov, chief of the Glavgosexpertiza in Russia, the reason for this was the unfinished electronic environment. According to him, at least Glavgosexpertiza is technically ready to accept the BIM model for consideration, but in 2017, not a single project came up where the information model met any standards, including the company's own standards of the project developer. Typically, models are provided that contain disparate data and do not allow them to be used in the examination. This indicates a lack of regulatory documentation in the field of BIM, as well as a low level of training.

Object technology dependency model (OTDM) allows you to see the various possibilities of overlap and intersection of works, as well as the difficulties that can occur in case of violation of the terms of the construction and installation works. This is one of the key factors that must be taken into account when summing up the state expertise. Therefore, along with the provision of all other documents, including the BIM-model, for the state examination of projects it is necessary to make also the OTDM.

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