

# Use of Technological Normals in the Development of a Building Information Model

*Vladimir Bazanov*<sup>1</sup>

Moscow State University of Civil Engineering, 129337, 26, Yaroslavskoye Shosse, Moscow, Russia

**Abstract.** At each stage of the life cycle, the digital model is characterized by a specific level of elaboration and respective attribute data of elements. At the stage of construction, the model is used for planning and organization of construction operations, progress control. It should contain elements providing fulfillment of the adopted organizational and technological solutions. For the formation of a building model, it is suggested to utilize technological normals of building processes. Technological normals contain basic requirements, parameters and factors for performance of particular types of construction and erection works, also special works; they also include the characteristics of required machines and mechanisms, tools, equipment and materials, labor inputs, staff qualifications and numbers, as well as the main technological solutions for execution of works. Normals can be made both for unit scopes of works and for individual structural elements, sections, assembly units. It would be useful to use normals as a catalog of standard elements for designing organizational and technological solutions in creating a building model. The structuring and standardization of catalogs (sets) of technological normals, their correlation with catalogs of building machines, structures and materials, will allow finding the most rational engineering and economic options during construction.

## 1 Introduction

Building information modeling (BIM) implies creation and use of a digital information model (DIM) of a capital structure at different stages of the life cycle: design, construction, operation. By DIM, we shall mean, pursuant to SP 301.1325800.2017 “Building information modeling. Rules for the organization of work by the production and technical departments”, an object-oriented parametric model digitally representing object characteristics (physical, functional, etc.) as a totality of information-rich elements.

Based on the tasks that require visualization of construction processes, there are several possible scenarios of using a four-dimensional construction information model (hereinafter, CIM or 4D-model): design, verification of the digital information model, modeling of the master plan (including the layout plan), modeling of building DIM (a temporary model with resource allocation), organizational modeling, logistical support, financial and economic modeling [1, 2].

---

<sup>1</sup> Corresponding author: [bazanov\\_kim@mail.ru](mailto:bazanov_kim@mail.ru)

The construction information model should contain elements describing substantiated organizational and technological solutions for project construction: project breakdown into work zones, areas, nodes; referencing structural elements and parts of a project to appropriate cycles of construction operations (underground, above-surface, start-up, and so on), types and time-schedules of works; construction site organization, arrangement of machines and mechanism; schedules of resources, etc.

It should be noted that at present the issues of creation information models at the project design stage have been developed in sufficient detail. The issues of organizational and technological engineering in respect of CIM have been developed to a lesser degree and are studied by researchers both in this country and abroad [3, 4].

The optimal selection of tower cranes (taking into account the regulatory requirements and standards, technical characteristics and minimal costs) and their arrangement on a construction site can be done using the methods of integer linear programming [5], while use of 4D-models allow eliminating possible spatial collisions at the stage of preparation for construction [6].

Development of a **4D-model** for construction site organization is used not only for planning the organization of works, but also for the risk management purposes to ensure safety of works in case of project reconstruction in confined spaces [7, 8].

The issues of construction site layout alterations according to the construction schedule are important for safe accommodation of personnel, materials and equipment. Using the data from BIM and genetic algorithms of optimizations, options of automated systems of creating models of arrangement of temporary facilities on a construction site with regard to staff movement routes and space confinement are developed [9, 10].

Application of photogrammetry as part of information modeling technology enables a multi-criteria selection of options in the drafting of a master plan (layout of mechanisms, temporary buildings and utilities on a construction site) [11].

Geolocation with a spatial 3D-model makes it possible to monitor the schedule of works, automate generation of reports, and plan performance of works with the help of a 4D BIM-model [12].

The level of software in the field of development of organizational and technological documentation does not yet support automation of design engineering. The necessity of a systems-based approach both to the process of engineering the organizational and technological documentation and to development of required digital technologies is noted [13].

The transition from the project 3D-model to the construction 4D-model is associated with referencing spatial model elements to the time sequence of construction works being performed, breaking the model down into work zones and work performance areas [14]. Efficient usage of a construction information model is possible only in case of its development and support by joint efforts of design engineering companies and contractors. The current regulatory documentation and the system of organizational and technological preparation of construction need to be adjusted with regard to specific features of information technologies [15-16].

Usage of international standards and foreign software cannot cover the demands of the Russian building industry because each country has its own peculiarities, different technologies, different requirements, and as regards BIM – different libraries of elements of organizational and technological solutions, too. Many fields of activities cannot be standardized at the international level, in particular because of differences in the approaches of Russian and foreign science and practice. Introduction of information modeling technologies requires a balanced approach including development of domestic or adaptation

of foreign standards to view models and data interchange formats for construction projects [17-18].

The project 3D and construction 4D models are generated at different stages of the project life cycle and by different participants of construction. The process of generation of a construction information 4D-model, underpinned by establishment of the sequence of work processes and referencing 3D-model elements thereto, is connected with considerable manual rather than automated works [19].

A construction model should contain elements, which are sufficient to make sound decisions during planning and progress control, without excessive detailing of a 3D-model. Detail elaboration is not strictly limited, but it is necessary to understand what level of details is minimally sufficient to avoid splitting files into dozens and hundreds of elements, which will be hard to coordinate later, and in general, it is a waste of time [20].

The process of construction model formation can be divided into several consecutive stages. For the stage of project DIM development, используются программы Allplan, Graphisoft ArchiCAD, Autodesk Revit programs or their domestic analogs: Renga, NanoCAD, Model Studio CS, etc., are used. At the next stage, the structure and sequence of construction processes, scopes of works are determined, the project is broken down into areas and zones of works. Thereafter, labor and material and technical resources are calculated (the requirement for staff, electric power, water, temporary buildings and facilities etc. is calculated), time schedules and network diagrams, schedules of resources are prepared, construction site planning is carried out (the master plan is developed). Time schedules of construction (the Gantt charts) are prepared by specialists themselves - in Oracle Primavera or Microsoft Project, manually or with the help of templates of previous construction projects. Time schedules and the 3D model are combined using Navisworks, Microsoft Project, Synchro Pro, 4D Virtual Builder, EXEL Manager, supplementary plug-ins to Autodesk Revit, or their domestic analogs: Plan-R, "1C: ERP. Construction Company Management 2", SIGNAL Tools, Multi-D, NS Project, GanttPRO, Vitro PLANNER.

So, the initial stage of construction model generation – establishment of the structure of works, formation of flows, breakdown into work zones with identification of the labor input, selection of the main machines and mechanisms – is mostly the manual work of contractors' specialists carried out based on their work experience and using dissimilar software.

The purpose of the study is finding elements and their attributive composition for development of BIM-catalogues characterizing normalized (standardized) technological solutions by types of construction works and utilized during automated selection of organizational and technological solutions at the stage of construction preparation and generation (formation) of a construction digital model.

## **2 Materials and Methods**

Analytical review of studies on the development and application of building informational models, selection of organizational and technological solutions during formation of building models.

Overview of usage of technological normals in the construction and other sectors. Analysis of the possibility and practicability of using technological normals of construction processes as BIM-catalogs for automated selection of organizational and technological solutions during formation of a construction digital model.

### 3 Results

The project 3D-model requires special adaptation for construction tasks – planning and management of construction of a structure. Project model elements are inconsistent with the construction model purposes in most cases because it is necessary to do additional breakdown of the model into areas, work zones, tiers, their reference to schedules of works according to detail design drawings, construction work programs, and so on.

The organizational and technological design engineering at the stage of construction preparation consists in determining the following data: types and sequence of construction works, project breakdown into work zones for flow production, calculation of labor input and requirement in material and technical resources. The above data have almost the same structure and content as technological normals (hereinafter, TN) of construction processes. The approximate composition of characteristics (indices) of a technological normal is given in table 1.

**Table 1.** Composition of the Construction Process Technological Normal

<b>Index (attribute)</b>	<b>Index Composition or Content</b>
Cycle of building construction	Underground, above-surface, finishing, ...
Type of works	Earthwork, erection, concrete, other
Composition of works	All processes including the sequence and methods of their performance
Scope of works	Scope for which the technological normal is designed
Work labor input	Labor input for the whole scope
Staffing	Staff numbers and qualifications*
Building machines and mechanisms*	Technical resources to be used: list of machines and mechanisms
Materials*	List and quantity of building structures and materials to be used
Calculation of labor input	Calculations on the basis of which the labor input has been determined
Material and technical resources*	Materials, equipment and tools, accessory equipment used - (the list and quantity)
Technology of performance*	Description of the technology of construction work performance
Requirements to quality control of works*	Technical requirements to performance of works
Cycle of building construction	Underground, above-surface, finishing, ...

\*) characteristics from related BIM-libraries (if there are any)

Taking into account the fact that the normal of any production process is designed based on rational organizational and technical conditions of production, it would be practical to use TN as elements of organizational and technological solutions in BIM-catalogs at the stage of automated formation of the construction digital model.

### 4 Discussion

Project information model elements can have different levels of detailing determining completeness of element elaboration: from LOD 100 to LOD 500. The level of detailing determines the quantity of graphical and non-graphical (attributive) information required for a particular element of the information model at a particular stage of its development. In the creation of a BIM-model, basic or standard elements are used, which are grouped into libraries of information model components (BIM-catalogs, BIM-libraries). As for the construction, these may be, depending on specific features, the libraries of structural elements or elements of engineering systems: beams, slabs, columns, doors, elements of utility networks, machines, mechanisms, etc. For a library to be a constructor from which elements a model is assembled, such elements must be classified and possess same sets of attributes. This also facilitates upgrade of elements in future, addition of new elements into a library, deletion of poor-quality or outdated elements.

As elements for BIM-catalogs containing standard organizational and technological solutions (by analogy to BIM-catalogs of structural elements and elements of engineering systems), it would be practical to use technological normals of construction processes.

Normals, as part of the general system of normalization, unification, and standardization, are used for typification of architectural planning solutions (planning normals), structural (normals of standard elements, structural normals), technological (technological normals), organizational solutions (organizational and technological management normals), and serve the basis for the development of cost estimate standards [21-23]. The development and introduction of technological normals accelerates the process of preparation of construction simultaneously reducing costs on the preparation and production of construction products, allows to diminish the range of standard processes employed to the most rational (efficient) taking into account the analysis of completed works, experience of their design and production, and mechanisms and materials used.

According to SP 301.1325800.2017, the construction information model is developed in the production and technical department of a building organization on the basis of a project model. It is a rather laborious and critical process. The structure of a construction information model also includes different levels of decomposition: projects - areas – cycles of works – types of works – work zones, et al. All spatial elements of a project model must be correlated to the construction model levels and linked to types of works, work zones, etc. For each element of a construction model (system, structure), the following parameters (attributes) with respect to organizational and technological solutions should be determined:

- construction technology,
- construction equipment (machines, mechanisms, tools, etc.)
- erection period (labor input + staffing)
- list and cost of materials,
- information about the cost of works,
- progress control method.

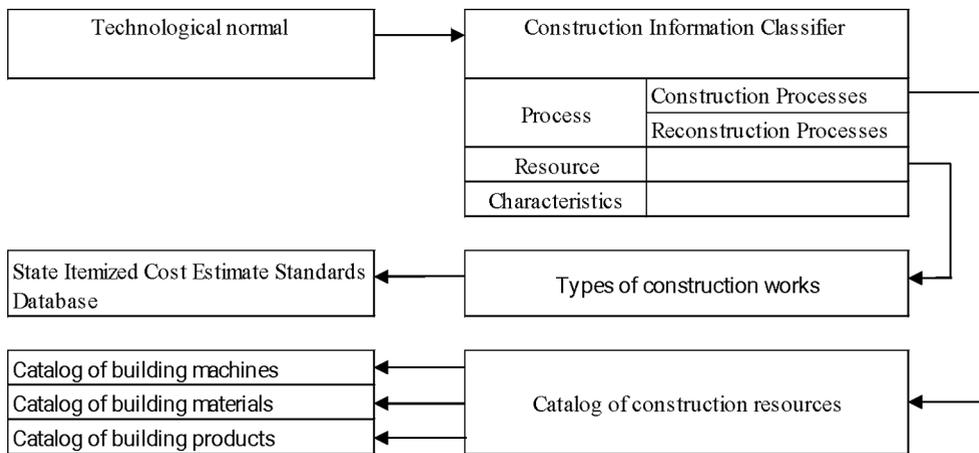
The same parameters include the technological normal (hereinafter, TN) developed for standardized construction processes includes the same parameters [24]:

- the list of works included into the complex to receive finished products;
- the sequence and methods of their performance;
- scopes of works, labor input therein, staffing, duration of each process,
- main building machines.

The technological normal can be compiled for a specific scope of work – unit or for one work zone (area), for the whole building/facility in general if it cannot be broken down into work zones in organizational and technological terms.

The TN library should facilitate finding necessary information in the course of construction model formation. To this end, the search system of the library must be based on the Construction Information Classifier and Construction Resources Classifier, also to related BIM-libraries of: building machines and mechanisms, engineering systems and equipment, accessory equipment with its digital models; labor resources with detailing to the profession (specialization) and cost of the resource per hour, cost estimate standard databases (fig. 1).

The structure of the construction information classifier (CIC) is based on the basic categories for modeling the main processes of the construction sector: “result”, “process”, “resource”, and “characteristics”. Each of the basic categories is subdivided into a number of separate classes. For instance, basic category “resources” comprises building products, building materials, secondary resources (machines, mechanisms, etc.), labor resources, as well as construction information. To expand the classification capabilities, in addition to the main classes mentioned in CIC, it is allowed to add user’s types of classes and user’s aspect (object view method), as well as user’s attributes or properties.



**Fig. 1.** Schematic diagram of correlation between the BIM-catalog of technological normals with BIM-catalogs of construction resources

This correlation of TN catalogs with other libraries via CIC will allow to update normals in view of the development and upgrade of material and technical resources, use the most rational variants of normals with regard to the development of technologies and equipment, appearance of new materials.

After a respective element (normal) has been chosen, the requirement in efforts and means is automatically formed: doers, machines, mechanisms, tools, materials, labor costs.

Elements of BIM-libraries can be created in different ways: by users while working on projects; producers of BIM-tools (software); manufacturers of structures, building materials, machines and equipment; special governmental structures. There is no unified national library of information model components, yet; the issue of library structure (a pooled storage of elements or a set of hyperlinks to respective catalogs) has not been solved, the time limits and doers have not been determined. At present, such kind of libraries exist only as local practices at large-scale organizations, private and corporate libraries, for example: BIM STANDARD FAMILY, BIM LIB, and KNOW-HOUSE. In Russia, it is necessary to create national libraries of TIM-components, because as regards

organizational and technological solutions (OTS), there are differences between foreign and domestic standards, rules and construction practices.

## Conclusions

Currently, software for creation of project 3D-models is sufficiently well developed. The project model requires special adaptation to construction tasks – facility construction planning and management associated with a large scope of manual work. For automation of the formation and selection of organizational and technological solutions at the stage of construction preparation – organizational and technological engineering within the frames of CIM, it is suggested to develop BIM-catalogs (libraries) of organizational and technological solutions, the elements of which would be the technological normals of the construction processes. TN comprises the following tentative set of basic parameters: type of works, technology applied, machines, materials, labor input. BIM-libraries of TN can be linked to catalogs of machines and mechanisms, materials, cost estimate standards. Development of such catalogs will assist acceleration of the work of selecting OTS during development of technological documentation, on the one hand, and establishment of economic efficacy of planned solutions compared to cost estimate standards, especially when the resource index method of drafting cost estimate documentation is used.

The following directions should be identified for further studies: classification and structuring of elements of libraries of technological normals, development of TN for different types of works, standardization of input and output parameters for the automated calculation. Development of single standard of information representation for information model components should be discussed separately.

## References

6. (54) R. Politi, E. Aktaş, E. İlal, *Project Planning and Management Using Building Information Modeling (BIM)*, 13th International Congress on Advances in Civil Engineering, 12-14 September 2018, Izmir/TURKEY (2018)
17. (70) G.A. Sentosa *et al*, *IOP Conf. Ser.: Earth Environ. Sci.* **1169** 012033 (2023). DOI 10.1088/1755-1315/1169/1/012033
0. (58) R. Charef, H. Alaka, S. Emmitt, *Beyond the third dimension of BIM: A systematic review of literature and assessment of professional views*, *Journal of Building Engineering*, **19**, 242-257 (2018), <https://doi.org/10.1016/j.jobe.2018.04.028>
24. (14) V.V. Filatov, A.D. Pestrikova, L.A. Adamtsevich, *Domestic Experience in the Development of Information Modeling Technologies*. *Promyshlennoe i grazhdanskoe stroitel'stvo [Industrial and Civil Engineering]*, **9**, 80-87 (2023). (In Russ.). DOI: 10.33622/0869-7019.2023.09.80-87
9. (60-1) D. Briskorn, M. Dienstknecht, *Mixed-integer programming models for tower crane selection and positioning with respect to mutual interference*, *European Journal of Operational Research*, **273**, Issue 1, 160-174 (2019), <https://doi.org/10.1016/j.ejor.2018.07.033>
10. (60-2) Y. Ji, F. Leite, *Automated tower crane planning: leveraging 4-dimensional BIM and rule-based checking*. *Automation in Construction*, **93**, 78-90 (2018). DOI:10.1016/j.autcon.2018.05.003
11. (60-4) M. Lucarelli, E. Laurini, P. De Berardinis, *3D and 4D modelling in building site working control*, *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*,

- XLII-2/W9**, 441–446 (2019),  
<https://doi.org/10.5194/isprs-archives-XLII-2-W9-441-2019>
8. 15. (67) K. Hyunjoon, A. Hongseob, *Temporary Facility Planning of a Construction Project Using BIM (Building Information Modeling)*, *Computing in Civil Engineering*, 627-634 (2011). [https://doi.org/10.1061/41182\(416\)77](https://doi.org/10.1061/41182(416)77)
  9. 12. (61) S.S. Kumar, J.C.P. Cheng, *A BIM-based automated site layout planning framework for congested construction sites*, *Automation in Construction*, **59**, 24-37 (2015), <https://doi.org/10.1016/j.autcon.2015.07.008>.
  10. 14. (66) K. Schwabe, S. Liedtke, M. König, J. Teizer, *BIM-based Construction Site Layout Planning and Scheduling*, 16th International Conference on Computing in Civil and Building Engineering, 679-686 (2016),  
[http://www.see.eng.osaka-u.ac.jp/seeit/icccbe2016/Proceedings/Full\\_Papers/086-352.pdf](http://www.see.eng.osaka-u.ac.jp/seeit/icccbe2016/Proceedings/Full_Papers/086-352.pdf)
  11. 8. (60) R. Kontrimovičius, L. Ustinovichius, *BIM-based prototype of a mathematical model of construction planning*, *Journal of Civil Engineering and Management*, **29**(1), 1–14 (2023). DOI:10.3846/jcem.2023.18313.
  12. 16. (68) B.F. Silveira, D.B. Costa, *Method for automating the processes of generating and using 4D BIM models integrated with location-based planning and Last Planner® System*, *Construction Innovation*, Vol. ahead-of-print No. ahead-of-print. (2023).  
<https://doi.org/10.1108/CI-02-2022-0030>
  13. 1. (44) P.B. Kagan, *Improving the effectiveness of organizational and technological design in construction due to its modernization using modern digital technologies*, *Russian Journal of Resources, Conservation and Recycling*, [online] **1**(7) (2020). Available at: <https://resources.today/PDF/09INOR120.pdf> (in Russian). DOI: 10.15862/09INOR120
  14. 5. (15) Sh. Staub-French, A. Khanzode, *3D and 4D modeling for design and construction coordination: Issues and lessons learned*, *Electronic Journal of Information Technology in Construction*, **12**, 381-407 (2007)
  15. S.I. Pimenov, *Construction information model*, *Construction and Geotechnics*, **13**, 3, 72-84 (2022). DOI:10.15593/2224-9826/2022.3.07
  16. 7. (56) L.A. Oparina, *Application of information modelling technologies for construction time management*, *Smart Composite in Construction*, **2**, 2, 48-55 (2021). DOI 10.52957/27821919\_2021\_2\_48
  17. 3. (49) A.V. Skvorcov, *BIM data models for infrastructure*, *SAPR i GIS avtomobil'nyh dorog [CAD and GIS of highways]*, **1**(4), 16-23 (2015). (In Russ.). DOI:10.17273/CADGIS.2015.1.2
  18. 13. (62) A. Sampaio, N. Gomes, A. Gomes, A. Sanchez-Lite, *Multi-Project in an Integrated BIM Model: Clash Detection and Construction Planning*, *Journal of Software Engineering and Applications*, **15**, 345-358 (2022). doi: 10.4236/jsea.2022.1510020.
  19. 18. (71) O. Doukari, B. Seck, D. Greenwood, *The efficient generation of 4D BIM construction schedules: A case study of the Nanterre 2 CESI project in France*. *Front. Built Environ*, 8:998309 (2022). DOI: 10.3389/fbuil.2022.998309
  20. 19. (75) F.B. Vargas, F.S. Bataglin, C.T. Formoso, *Guidelines to Develop a BIM Model Focused on Construction Planning and Control*, 26th Annual Conference of the International Group for Lean Construction, 744-753 (2018). DOI: [doi.org/10.24928/2018/0450](https://doi.org/10.24928/2018/0450)

21. 21. (80) V.M. Lebedev, *System engineering and system components of construction production* [Sistemotekhnika i sistemokvanty stroitel'nogo proizvodstva], Moscow, INFRA-M, 226 p. (2019). (In Russ.).
22. 22. Order of the Ministry of Construction of Russia dated 18.07.2022 №577/pr “On approval of the Methodology for the development of estimate standards”, <https://minstroyrf.gov.ru/docs/226103/>
23. 23. L.A. Tsvetkova, T.R. Zabalueva, *The comparative analysis of russian and foreign standards regulating the creation of planning solutions of rehabilitation centers for people with disorders of the musculoskeletal system*, International Research Journal, **3**(45), 43-47 (2016). DOI: 10.18454/IRJ.2016.45.024
24. 20. (77) V.M. Lebedev, G.V. Belikova, *Modeling construction of monolithis concrete floors taking into account organizational - technological reliability*, The Bulletin of BSTU named after V.G. Shukhov, **3**, 51-56 (2017). DOI: 10.12737/25047