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Cost management technologies for construction projects in the context of introduction of information modelling

The overall business environment in the country has increased the importance of support for industries and raised pressure on the financial system. The construction industry holds a special place due to its set of socio-economic objectives, including the construction of housing, medical and education facilities, infrastructure in populated areas, etc. As of 2022, construction projects are to have digital information models to ensure data exchange between direct participants in the construction process, and in the course of interaction with state supervisory authorities. The article addresses the issue of pricing and construction cost estimation; the authors have identified the factors that prevent information modelling technologies from bringing extensive projected benefits. The authors emphasize the need for the state standardization of consolidated types of works, that make up a construction facility. This task is particularly relevant for an extensive list of social facilities, constructed within the framework of regular government procurement contracts. The compilation of catalogues of work types includes the development of flow charts and requires the involvement of versatile experts and specialists. Further, if these materials are available, cost parameters, or standard costs of structural solutions, become necessary and feasible. At present, there is a tiny set of approved standards, and their number does not grow. Some insignificant results have been achieved at the corporate level. The reason is the lack of a comprehensive approach, which is addressed in the article. Given the intensive implementation of information modelling technologies (IMT), IT companies get more and more involved in addressing the tasks and problems of the construction industry. Hence, they can make a significant contribution to new cost management technologies.

Keywords: *information modelling technologies, construction, construction cost, estimates, economic efficiency*

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INTRODUCTION

When construction projects are implemented, stakeholders tend to effectively apply information modelling technologies and use various special-purpose tools to automate business processes of project preparation and implementation. The main driver of application of information modelling software is the responsibility of contractors to draft the project documentation in the form of digital models for public contracts implemented as of 2022. Given that the government procurement far exceeds commercial construction, digitalization at the stages of design, construction, and operation of construction projects is accompanied by numerous grave problems. Hence, in 2021, the government procurement under the Federal Law 223 reached 9.3 trillion rubles, which exceeded the value for previous period by 15 %. Procurement under the Federal Law 44 reached 9.4 trillion rubles, which is 11 % more than in 2020[1], [2]. The shares of construction works and services within the framework of Federal Laws 223 and 44 exceeded 80 and 55 %, respectively. Against this background, the efficiency of information modelling technologies depends on the availability of information and reference materials in the digital form, including, inter alia, libraries of design solutions and cost standards broken down by types of work. The priority task is to develop libraries to ensure the efficient application of information modelling techniques. Experience has proven [1–3] that the industry does not possess such materials in full and the relevance of their development increases due to the requested transition to digital models.

MATERIALS AND METHODS

Experts and researchers point out the need to develop and implement mutually coordinated solutions at all stages of the project life cycle to ensure an effective transition to building information modelling technologies (IMT) [4–6]. BIM is to encourage the innovative development of the construction industry [7]. Besides, experts consider independent functional areas of application of information modelling technologies, which are crucial for the work process organization at construction enterprises. Hence, the authors of [6] consider the problem of enhancing the accuracy of estimates at different levels of construction projects. The method of construction budgeting using the information modelling technology is analyzed. Attention is drawn to the fact that 3D models cannot be used to calculate construction costs. The authors analyzed the breakdown of the workforce cost and its share in construction costs.

1 The volume of procurement in Russia by companies with state participation increased by 15 % in 2021. Date Views: 11.04.2022. URL: www.tass.ru/ekonomika/13569315?utm_source=rts-tender.ru&utm_medium=referral&utm_campaign=rts-tender.ru&utm_referrer=rts-tender.ru

2 RTS-tender: the volume of purchases of state companies in Russia increased by 15 % in 2021. Date Views: 11.04.2022. URL: www.rts-tender.ru/about/news/31012022

The cost analysis, made within the framework of a project simulated as a 3D model, is highly sophisticated, and it takes account of various architectural, design and other solutions. Given the array of construction resources, currently available on the market, one should know that methods of developing and presenting the future appearance of a construction facility vary. Therefore, selection of the criteria determining the final project concept to be accepted for implementation is an important issue. Obviously, cost management is the key point. In turn, cost management in information modelling programmes, or BIM, is a rather complex issue. Let's consider the principles of building information models to understand its essence.

Development of information modelling systems is a time consuming process. It encompasses initial data collection, staff training, organization of interaction within and between teams, accumulation of experience, reference materials and libraries of ready-made 3D solutions, which can significantly accelerate the design and implementation of a construction project. The experience of foreign countries [8, 9] shows that companies using sophisticated information modelling systems, including BIM, having been developing in this field for many years and even decades. Besides, it is not only the level of development and the capacity of individual businesses that is crucial, but also the development of private and public institutions promoting the use of BIM solutions by the industry as a whole and individual enterprises, in particular.

Therefore, the analysis of standard technical documentation in Russia shows proactive standardization of relevant processes and regulation of activities. To date, more than eight standards have been developed, namely GOST R 57310-2016, 57311-2016, 57563-2017, 57295-2016, 12006-2-2017, 12006-3-2017, 22263-2017, 57309-2016, 58439.1-2019, 58439.2-2019, which regulate:

- information handling guidelines;
- documentation requirements;
- management guidelines;
- data organization and exchange;
- knowledge libraries, etc.

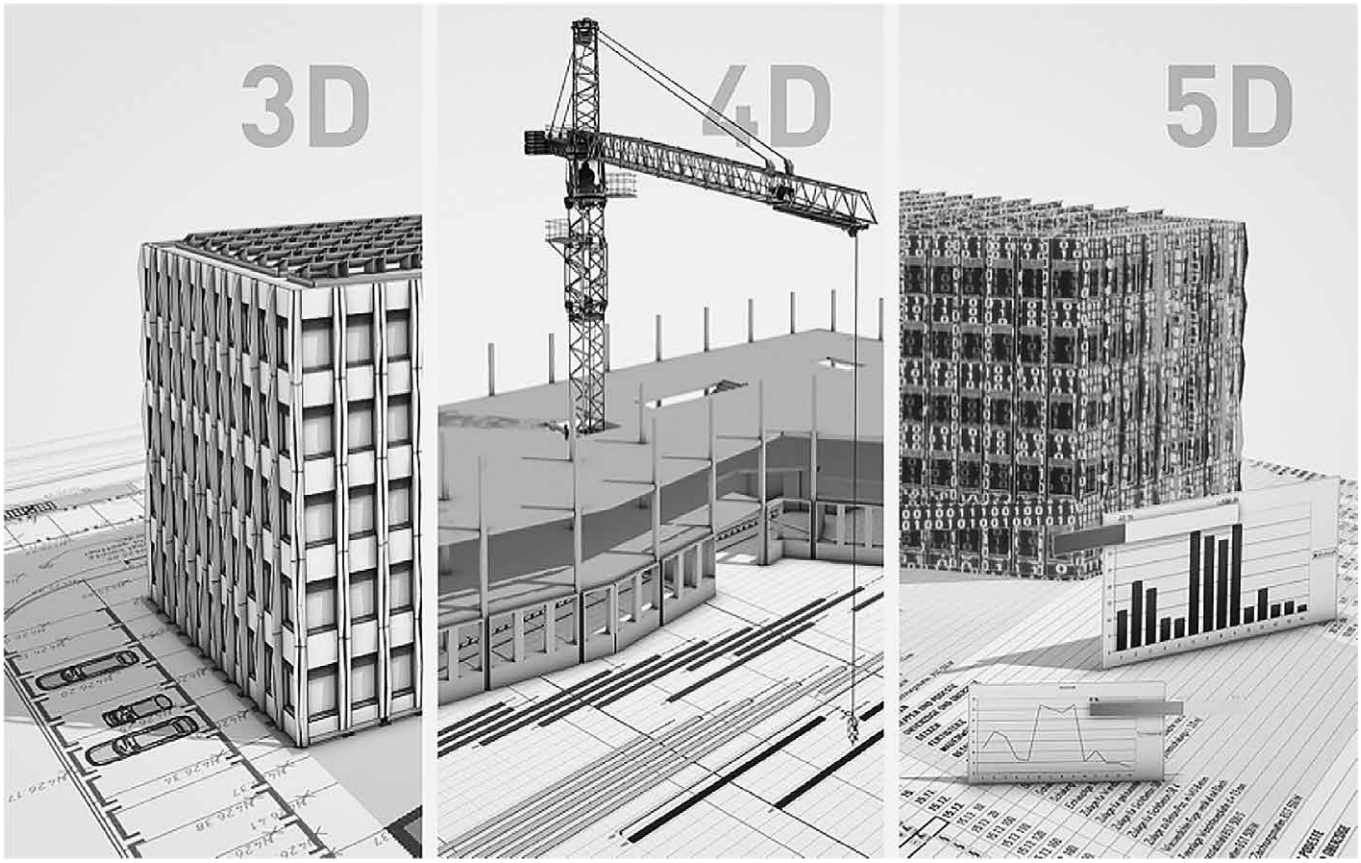
In addition, there are sets of rules SP 301.1325800.2017, 328.1325800.2017, etc., that contain the terminology and requirements for an information model, rules of information exchange between systems, etc. The model has three main levels (Fig. 1) depending on the applicable rules/regulations, the amount of information, the level of complexity of an information model and the presence of factors that may accelerate the project implementation. Further, 6D and 7D modelling affects operation stages, repairs, and reconstruction of the facility, etc. Hence, the ability and willingness of a construction organization to work at each of the 3–5D levels is a proof of its high competence.

The diagram in Fig. 1 shows that value management is at the top level. Critical factors that influence the ability of investors, customers, and contractors, involved in a construction project, to make management decisions are concentrated in the value parameters. Therefore, a construction company must be able to use BIM to promptly evaluate the proposed solutions, select and compare alternative options. The analysis of the pricing system in the construction industry shows that the design and estimation method is used for a detailed calculation of the cost of construction. The method is labour-intensive and assumes the availability of the readymade design documentation, including calculations, listed items and amounts of work, etc. Standard construction prices (SCP) are used to make an initial assessment of the project. The mission of SCP is to provide insight into the cost of a completed construction facility using its general characteristics. SCP are developed by the Ministry of Construction of Russia, and the database has SCPs broken down by the types of structures, including residential buildings, office buildings, educational facilities, etc. SCPs are the tool employed to calculate the cost of a construction facility at the stages of contribution of state funds and disbursement of budget proceeds and schedule the construction process. If the unit cost of a square meter of a construction facility is available, its total cost is calculated using the design floor area. A provisional standard cost indicator is provided in Table 1.

Hence, the final cost of a construction facility represents one figure, and it is impossible to determine the cost of an individual component to compare different construction options. The compilation has approximate design solutions illustrated in Fig. 2. For example, if piles are used in foundations, and the room partition is made of gypsum structures, or tongue-and-groove boards. Since no amounts or costs are specified, it is impossible to make swift changes in BIM cost modelling.

Table 1. An excerpt from "Consolidated Standard Construction Prices" NTSS 81-02-01-2022. Compilation 01. Residential Buildings

SECTION 3. MULTIFAMILY RESIDENTIAL BUILDINGS MEDIUM-RISE BUILDINGS (3–5 FLOORS)		
Indicator code	Parameter	Construction price as of 01.01.2022, thousand rubles
Table 01-03-001 Medium-floor residential buildings (3–5 floors) with a precast-monolithic frame **Indicator:** 1 m² of the total floor area of an apartment		
01-03-001-01	Medium-floor panel residential buildings (3–5 floors) with precast-monolithic frame with an apartment area of 5,100 m²	48.07
Table 01-03-002 Medium-floor residential buildings (3–5 floors) made of bricks **Indicator:** 1 m² of the total floor area of an apartment		
01-03-002-01	Medium-floor residential buildings (3–5 floors) made of bricks with an apartment area of 1,200 m²	67.69
01-03-002-02	Medium-floor residential buildings (3–5 floors) made of bricks with an apartment area of 3,200 m²	50.27
01-03-002-03	Medium-floor residential buildings (3–5 floors) made of bricks with an apartment area of 3,850 m²	43.33



3D BIM model
Information model executed at the design stage, it includes 3D geometry of the facility and attributive data of its components

4D BIM model
Information model drawn on the basis on the 3D model and supplemented by the solutions on construction organization as well as realized in the format of facility's change in time

5D BIM model
Information model drawn on the basis of the 3D model and supplemented by the data on the cost of works and materials

Fig. 1. Evolution of BIM solutions

Another tool that can meet the requirements of cost modelling is a set of standard prices for structural solutions (SPSS). The register of standard technical documents of the Ministry of Construction of Russia has "State Cost Standards".

Here, consolidated pricing standards applicable to structural solutions "81-02-22-2014) Part 22. Highways" are used[3]. We can conclude that the construction of a facility is broken down into certain types of independent assignments, and each has cost indicators. Hence, the construction of roads is broken down into the following items of work.

Section 01. Site preparation for construction.
Section 02. Road formation.
Section 03. Road wear.
Section 04. Man-made structures.
Section 05. Road furnishing.
Section 06. Installation of sidewalks and curbs.
Section 07. Road service buildings and facilities.

The list of work assignments, cost indicators and standard prices are provided for each position in each section (see Table 2).

Various alternative structural and design solutions, depending on the needs of the customer and future users of a construction facility, can be assessed using the cost indicators available for individual types of work. It should be admitted that the principle of deriving cost indicators for each type of works is widely used in the foreign practice. In contrast to the method of application of itemized state cost standards (GESN), a cost indicator allows for a less laborious initial estimation of the cost of a construction facility with a high degree of accuracy, as all fixed and variable costs are specified in this indicator (including the projected profit and overheads). The use of itemized state cost standards (GESN) is possible, as it allows for a clarification in terms of construction materials, other local issues, and in terms of the budget documentation, developed on the basis of the design documentation.

There is a strong demand for BIM-linked cost budgeting solutions. The reason is the deficit of resources at state institutions, lack of research support and task setting, insufficient links with the business community. And all these problems should be solved together. The following actions must be taken to improve the situation:

1) classification of construction facilities within the framework of a state order, breakdown of construction work and formation of cost indicators;

2) identification of types of work, development of flow charts and their approval within the framework of state reference books,

3 State Estimating Standards Consolidated Standards of the Price of Structural Solutions (NTsKR 81-02-22-2014) Part 22. Automobile roads. Technical part. Date views: 11.04.2022. URL: www.minstroyrf.gov.ru/docs/10281/?sphrase_id=1545290

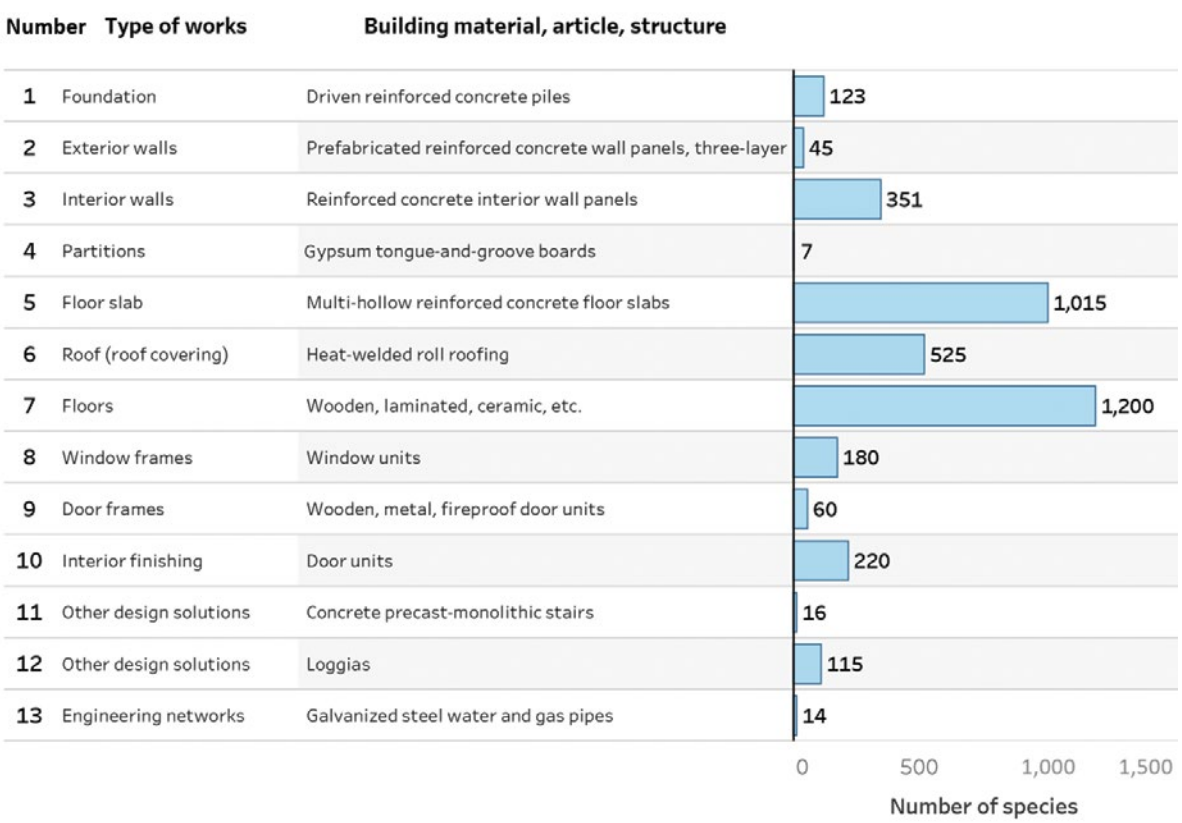


Fig. 2. The number of options for a residential building that has 6–10 floors according to Construction Price Standards 81-02-01-2021

for example, itemized state cost standards (GESN), Federal Unit Rates (FER), etc. Flow charts are needed to:

- systematize work processes, identify the need for resources to perform construction work on a particular construction site and develop standard costs for structural solutions (SPSS);

3) maintenance of catalogues of construction resources, which include all resources available in the SPSS. This approach allows for the state monitoring of the cost of construction resources in a more targeted way and focuses on the interests of public customers and contractors. Currently, there is a system of construction resources monitoring, which is too general, and, therefore, it does not respond to the needs of public customers;

4) development of volumetric and quantitative characteristics of construction resources in flow charts to update various indicators and have costs monitored by any interested persons.

It should be noted that this work can be only organized at the initiative of the Ministry of Construction of Russia and its subordinate structures due to the fact that the development of flow charts and cost

Table 2. An excerpt from the compilation of the standard price of highway design solutions SPSS 81-02-22-2014

Section 01. Site preparation for construction
Table 22-01-001 Tree felling
Composition of work:
01. Felling of trees. 02. Cutting of bushes. 03. Removal, unhooking, and skidding of tree-long logs. 05. Uprooting of stumps. 06. Shoveling dirt. 07. Area cleaning. 08. Loading, moving and unloading of stumps.
Measurement: 100 items

Cost indicator	Standard prices (rubles) as of 01.01.2014			
	22-01-001-01	22-01-001-02	22-01-001-03	22-01-001-04
Remuneration of construction workers	5,574.53	7,189.14	9,944.15	11,949.10
Operation of machines	8,836.12	9,089.74	11,816.13	13,724.46
Material resources	—	—	—	—
Equipment	—	—	—	—
Total	**14,410.65**	**16,278.88**	**21,760.28**	**25,673.56**

solutions requires a large number of design documentation. Another important task is to make flow diagrams. This task involves some research as criteria for such diagrams are unavailable. Let's make a list of basic principles to be applied to the generation of these diagrams.

Firstly, a flow diagram should specify a list of works to be performed on other sites, for example, items of work dealing with floors, ceilings, walls, foundations, etc.

Secondly, the flow diagram should contain interrelated items of work. For example, the installation of a monolithic reinforced concrete floor slab, beams and columns includes the installation of scaffolding and formwork. In addition, some items of work use gas cylinders, discs for angle grinders, welding electrons, etc. as materials and resources. It is difficult to assign specific rates to such resources when a traditional construction work budget, such as the one specified in the GESN, is made. Therefore, the generalization of work and resources, which in the end allows making a concrete slab with columns and beams, takes into account all auxiliary processes to identify a standard price of a particular structural solution. Subsequently, it expands the capabilities of information modelling (BIM).

RECOMMENDATIONS

Experts believe that over the past three years a quarter of the state contracts worth more than 4 trillion rubles were terminated, which led to an increase in problematic construction projects across the country. The industry predicts that by the end of 2022 the number of broken contracts will have increased by 20 %[4]. At the same time, according to the authors, advanced administrative actions will accelerate the implementation of IMT and increase the efficiency of construction clearly, although it will not eliminate any chronic problems. Basically, builders do not have enough money to complete the work. The approach, proposed by the authors, that is, their proposal to systematize and classify construction work using flow diagrams is a way to construct and building pursuant to an order, which is critical to the success of public construction projects. The basis of this systematization is a mechanism for preparing materials (libraries), to ensure a faster and more efficient design development for a construction project via the use of readymade digitized modules in the 3D format and a swift state expert examination procedure. Further, standard prices for structural solutions (SPSS) should become an efficient instrument at the stage of elaboration of the project concept by the customer within the limits of the funding. At the earliest stage, such a mechanism enables to abandon a project concept that will be impossible to implement in the future. Since the government takes no initiative to intensify the development of standards, the business community should do it themselves. Large enterprises, whose errors are extremely expensive, can develop price standards for design solutions based on their own experience and completed projects. Further, it is necessary to summarize the budget-related documents, certificates of work performed and other materials that specify the actual costs incurred in the process of construction. A large amount of information and digital data requires the use of specialized software. In terms of the methodology, some information can be extracted from the SPSS collections approved in the past to be updated for the future use. It is also advisable to address the research undertakings implemented in the past [10–12].

CONCLUSIONS

The current challenge of accelerated transition to information modelling technologies has identified chronic problems in the construction pricing methodology. The unavailability of tools, needed to identify costs at all stages of a construction project, limits the implementation of digital solutions. In addition, since no tasks are set by the state, anticipated ITM benefits cannot be obtained soon. In this regard, the construction business community, acting in alliance with developers of specialized software for the construction industry, should concentrate on developing specialized regulatory and reference libraries. In fact, they can start developing a system of digital standards for technical documents. The ability to simulate the cost of a construction facility using pre-calculated items of work improves the effectiveness of construction concepts, while the transparency of pricing in terms of consolidated types of work helps to identify weaknesses in project schedules and manage future risks.

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Технологии управления стоимостью строительных проектов при внедрении информационного моделирования

Общая экономическая обстановка в стране делает критически важной поддержку отраслей, увеличивая нагрузку на финансовую систему. Особое место занимает сфера строительства с массой социально-экономических задач, в том числе по строительству жилья, объектов медицины, образования, инфраструктуры населенных пунктов и др. С 2022 года реализация строительных проектов должна осуществляться с применением цифровых информационных моделей для обмена данными как между непосредственными участниками строительства, так и при взаимодействии с государственными контролирующими органами. В статье рассматривается проблема ценообразования и сметного нормирования строительной деятельности и определяются факторы, которые препятствуют получению высокого ожидаемого эффекта от применения технологий информационного моделирования. Авторы указывают на необходимость государственной стандартизации укрупненных видов работ, из которых складывается объект строительства. Особенно актуальной данная задача является для широкого перечня объектов социального назначения, которые выполняются в рамках регулярных государственных закупок. Создание каталогов видов работ включает в себя разработку технологических карт и требует привлечения экспертов и специалистов разного уровня. Далее, при наличии таких материалов необходимым и возможным становится разработка стоимостных показателей — нормативов цены конструктивных решений. В настоящее время имеется лишь совсем небольшая часть утвержденных нормативов. Их состав не расширяется. Наблюдаются незначительные результаты на корпоративном уровне. Причина состоит в отсутствии комплексного подхода, который раскрывается в статье. С учетом активного внедрения ТИМ, IT-компании начинают все больше включаться в задачи и проблемы отрасли строительства и для разработки новых технологий управления стоимостью могут внести существенный вклад.

Ключевые слова: *технологии информационного моделирования, строительство, стоимость строительства, сметы, экономическая эффективность*

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