On the issue of improving the accuracy of construction cost calculations at the pre-project stage

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Abstract. The article deals with the issues of determining the cost of construction products on the territory of the RF at the pre-project stage. The results of the obtained calculations of the construction cost at the pre-project stage are analyzed using various methods. The disadvantages of determining the cost of construction using the enlarged collections of the CPS-2020 are revealed. Ways to improve the accuracy of construction cost calculations at the pre-project stage are proposed, in particular, by applying extrapolation formulas that are currently not available in the methodology for calculating construction costs based on enlarged collections. It is proved that the application of the proposed formulas significantly increases the accuracy of calculations, bringing the obtained values closer to the most accurate calculation of the construction cost – the result of the consolidated estimated calculation of the construction cost, compiled within the project documentation.

1. Introduction
Currently, in the context of reforming the russian pricing system in construction, the accuracy of construction cost calculations at the pre-project stage is of great importance [1]. The cost of construction products is a significant part of the invested budget funds, so the process of determining the construction price should be considered as one of the most important stages of the successful implementation of an investment project. All of the above indicates that there is a need for a more in-depth and comprehensive study and, if necessary, improvement of methods for estimating the cost of construction during the entire cycle of implementation of an investment and construction project [2].

At the pre-project stage, when it is impossible to calculate the estimated cost of construction in accordance with accurate design data, there is a need to use methods for determining the estimated cost based on analogous objects or applying enlarged estimated standards, in particular, enlarged construction price standards (CPS). Currently, the current version is the CPS-2020, which was put into effect by the order of the ministry of construction of the RF dated December 30, 2019 [3]. All participants in investment and construction activities, especially customers, are interested in the most reliable determination of the estimated cost. Accordingly, an unreliably determined estimated cost of construction for the investor negatively affects the entire financial planning process, which determines the relevance of the chosen topic.

2. Problem Statement
Consolidated construction price standards (CPS) designed to determine the cash requirements needed to create a power of construction products for planning (justification) of investments (capital
investments) to capital projects and other purposes established by legislation of the RF, objects, construction of which is financed with attraction of means of budgets of budgetary system of the RF, funds of legal entities established by the RF, constituent entities of the RF, municipal formations, legal entities whose share in the authorized (pooled) capital of the RF, constituent entities of the RF, and municipalities is more than 50 percent [4].

The purpose of the CPS is shown in the Figure 1. [5].

Consolidated construction price standards (CPS) are intended for:

- Investment planning in the form of capital investments
- Verification of the accuracy of determining the estimated cost of capital construction projects, audit
- Estimates of technical and economic indicators specified in the design task

**Figure 1. “Purpose of the CPS”**.

Since the estimated cost of the object, the construction of which is planned at the expense of budget funds, should not exceed the cost calculated by the CPS, we can say that it is a kind of price guide [6]. In order to reliably determine the estimated cost using the collections of the CPS, it is necessary to correctly take into account a significant number of coefficients in accordance with the selected collection and additional costs. Based on the above, it becomes clear that the calculation of the estimated cost of construction for the CPS is a responsible task, which in the final result directly affects the determination of the amount of monetary investment.

In connection with all the above, we can identify a number of problems that make it difficult to plan investments in future budgets. In practical terms, setting the most accurate construction price at the planning stage will increase competition between contractors: auctions will be won by those companies that can meet the specified price limits or find more cost-effective solutions while maintaining quality [7]. Such a system has long existed in western countries with developed market economies [8, 9, 10].

3. Research Questions
The greatest importance in considering issues related to determining the cost of construction at the pre-project stage is the lack of accuracy of calculations, due to shortcomings in the existing estimate and regulatory framework in construction in terms of enlarged standards.

4. Purpose of the Study
The purpose of the scientific article is to identify problems and further prospects for determining the estimated cost of construction with budget financing. Based on the data obtained in the course of the study, it is possible to form measures aimed at correcting the existing budget and regulatory framework for improving the accuracy of calculations at the pre-project stage for enlarged collections.

5. Research Methods
The problem of determining the estimated cost is the most painful problem in the construction industry. It affects all participants in the process, from the state as an investor to contractors as implementing investment and construction projects. And in the end, all participants suffer from the inefficiency of the pricing system in one way or another [11].

Pricing and estimated rationing is an integral part of the construction industry, which combines a set of regulatory legal documents and estimated standards that are designed for effective planning and spending of budget funds.
Because the most important component of calculating the amount of investments is the determination of the estimated cost, there are questions relating to valuation of the construction and use of estimate standards in the financing of objects of construction from the state budget at various stages of realization of investment construction project, including pre-project stage and at the stage of facility operation [12, 13].

One of the methods for determining the estimated cost of construction at the pre-project stage involves the use of enlarged collections of the CPS.

Table 1 contains a list of costs that are accounted for and not accounted for in the CPS [14].

| CPS take into account                  | CPS are not taken into account                                             |
|---------------------------------------|---------------------------------------------------------------------------|
| Construction and installation works   | Worker's travel expenses                                                  |
| Equipment                             | Transportation of workers                                                 |
| Temporary buildings and structures    | Costs for construction and maintenance of shift camps                     |
| Increase in the cost of work in winter| Payment for land and land tax during the construction period              |
| Design and survey work               | Payment for connection to external engineering networks                  |
| Examination of project documentation | Additional costs that arise under special conditions of construction, the constrained conditions of production of works |
| Architectural supervision            |                                                                           |
| Customer service                     | Special conditions for the construction of an object are taken into account by the coefficients provided for in the technical parts of the CPS collections |
| Construction control                 | Other costs that are not typical for the construction of the corresponding type of building |

The procedure for calculating the cost of an object planned for construction using the CPS is shown in Figure 2.

1. Collection of initial data on the object planned for construction:
   - functional purpose of the object
   - capacity characteristics (total area, number of seats, etc.)
   - start and end date of work on the object
   - region of construction

2. The selection of appropriate CPS:
   - it is carried out according to the corresponding collections, taking into account the functional purpose, capacity of the object and other characteristics

3. Selection of necessary coefficients:
   - coefficient of transition from the prices of the base district (Moscow region) to the price level of the RF subjects
   - coefficients in the technical parts of the CPS collections [15].
   - in accordance with the territorial budget standards
   - coefficients in accordance with the technical parts of the CPS collections
Figure 2. “Procedure for calculating the cost of construction using collections of CPS”.

To analyze the accuracy of the calculations for aggregate ratios were calculated the estimated cost of construction method of the integrated standards and on the consolidated estimate calculation of cost of construction of the following facilities, construction of which is financed from the state investment is a secondary school 154 seats in the village of Tselinn, Nukutsk district, Irkutsk region; school of 520 students in the city of Nizhneudinsk, Nizhneudinsk district, Irkutsk region.

Table 2 provides a comparison of the estimated cost of construction of objects determined by the above methods.

**Table 2. “A comparison of the estimated cost specified integrated method and consolidated estimated calculations”.

| Name of the object                                          | Method for determining the estimated cost of construction | Deviation, % |
|-------------------------------------------------------------|----------------------------------------------------------|--------------|
| Kindergarten for 220 places, located at the address: Irkutsk region, Angarsk, microdistrict 22 | Consolidated calculation of construction costs, thd. rub. | 21.13 %      |
|                                                             | Summary estimate of the construction cost thd. rub.      |              |
|                                                             | 389 190,44                                             | 306 963,97   |
| Secondary school for 154 places in the village of Tselinn, Nukutsk district, Irkutsk region | 242 182,15                                             | -10.55 %     |
| Secondary school for 520 students in Nizhneudinsk, Nizhneudinsk district, Irkutsk region | 682 432,16                                             | 13.31 %      |
|                                                             | 591 625,71                                             |              |

According to table 2, it can be seen that the estimated construction cost obtained by the method of enlarged standards for two objects, namely a kindergarten for 220 places and a school for 520 students, is more than the estimated construction cost obtained by the consolidated estimate by 82 226,47 thd. rub. or by 21.13% and by 90 806,45 thd. rub. or by 13.31%, respectively. This deviation indicates a significant consolidation of prices in the method of consolidated standards.
While the estimated cost of building a school for 154 students, obtained by the method of enlarged standards, is less than the cost obtained by the consolidated estimate by 25,545,01 thd. rub. or 10.55%.

The reduction in the estimated cost of building a school for 154 students by the method of enlarged standards in comparison with the estimated cost obtained by the consolidated estimate may be due to the fact that the new collection of the CPS 81-02-03-2020 “Educational facilities” in section 2 – general education facilities provides only 3 standards, namely, the construction of a school for 550 places, 800 places and 1100 places, so to determine the cost of building a school for 154 students, the minimum number of places from the table was taken – 550 places. In this collection of the CPS, the construction price standard on 01.01.2020 1 places norms for 550 places amounted to 834,76 thd. rub., while in the collection of the CPS 81-02-03-2017 “Objects of education” in section 2 – objects of general education, 9 norms are provided, namely, the construction of a school for 100 places, 200, 275, 400, 550, 700, 800, 1000 and 1,100 seats, respectively. In this collection the standard construction price of 1 place can be calculated using the formula 1 interpolation:

\[ P_b = P_c - (c - b) \cdot \frac{P_c - P_a}{c - a} \]  

(1)

\( Pb \) - the calculated indicator;  
\( Pa \) and \( Pc \) - boundary indicators from the tables in the collection of the CPS;  
a and c - parameter for boundary indicators;  
b - parameter for the defined indicator, \( a < b < c \).

As a result of calculation according to this formula in the collection of the CPS 81-02-03-2017, the standard construction price for 01.01.2017 for 1 place was 1 346,61 thd. rub., which is 61.3% more than in the new collection of the CPS 81-02-03-2020.

Therefore, a decrease in the estimated cost of construction of the school at 154 students received the integrated method in comparison with the estimated cost of construction, certain consolidated estimates due to the fact that in the new edition of the collections of the CPS is the minimum rate in section 2 is 550 places, the technical part of the book is not provided by the application of the formula of extrapolation, in this regard, you have to take a rate of 550 seats and the result is a significant reduction in cost.

As a result of the identified problem, a comparative analysis of the number of standards presented in some collections of CPS editions of 2017 and 2020 was carried out, which is presented in table 3.

**Table 3** “Comparative analysis of the number of standards in the collections of CPS in the 2017 and 2020 editions”.

| Name of the norm                     | The number of rules | Deviation |
|--------------------------------------|--------------------|-----------|
|                                      | **CPS 2017** | **CPS 2020** |       |
| CPS 81-02-03 “Educational facilities”|                     |           |       |
| Kindergarten                         | 5                  | 3         | 2      |
| Kindergartens with swimming pool     | 4                  | 2         | 2      |
| School                               | 9                  | 3         | 6      |
| Schools with swimming pools           | 1                  | 1         | 0      |
| Art schools, music and art schools   | 1                  | 1         | 0      |
| Educational, training and laboratory buildings | 1      | 1         | 0      |
| CPS 81-02-04 “Health facilities”     |                     |           |       |
| Hospitals                            | 4                  | 4         | 0      |
| Children’s hospital                  | 3                  | 3         | 0      |
| Medical building                     | 3                  | 2         | 1      |
| Dispensaries                         | 1                  | 1         | 0      |
| Polyclinics                          | 3                  | 3         | 0      |
| Children’s polyclinic                | 2                  | 2         | 0      |
Thus, according to the results of comparing the collections of the CPS in the 2017 and 2020 editions, it is clear that a significant reduction in the norms occurred in the new edition of the collection of the CPS 81-02-03-2020 “Objects of education”. This reduction and lack in the technical collection of formulae of extrapolation in the direction of increase or decrease of indicators leads to inaccurate calculations of the estimated cost of construction, namely to an underestimation of the estimated cost compared with the estimated value obtained the summary estimates.

According to the calculations of the estimated cost of construction by various methods and the analysis performed, it can be concluded that the use of enlarged estimated standards makes it possible to estimate the cost of construction at the pre-project stage to lay funds in future budgets, but with insufficient accuracy. As the estimated cost of the project, construction of which is planned at the expense of budget funds, shall not exceed the value calculated for the CPS, we can say that it is a kind of benchmark, as seen in the performed calculations the benchmark at two sites too high, it can lead to an unjustified increase of committed funds in the budget, and 1 object reference point too low, which also entails negative consequences, for example, lack of funds to complete construction of the facility.

6. Findings
In connection with the results of calculations and analysis, to improve the accuracy of determining the cost of construction according to enlarged standards, it is necessary in the technical part of the new collections of the CPS 81-02-03-2020 to provide for the use of a formula not only for interpolation, but also for extrapolation in the direction of decreasing or increasing indicators. Extrapolation formulae (2) and (3) are proposed.

The formula of extrapolation in the direction of decreasing indices

\[ P_b = P_a - \frac{P_c - P_a \cdot (a - b)}{c - a} \]  

(2)

The formula of extrapolation in the direction of increasing indices

\[ P_b = P_c + \frac{P_c - P_a \cdot (b - c)}{c - a} \]  

(3)

\( P_b \) - calculated indicator;
\( P_a \) and \( P_c \) - border indicators from the tables of this collection;
\( a \) and \( c \) - parameter for boundary indicators;
b - parameter for the indicator to be determined, \( a > b < c \).

If we apply the proposed formula of extrapolation in the direction of decreasing indicators when calculating the cost of building a school for 154 students, the cost of building 1 place will be respectively:

\[
P_b = 834,76 - \frac{725,55 - 834,76 \cdot (550 - 154)}{800 - 550} = 978,92 \text{ thd. rub.}
\]

The resulting figure is 14.7 % more than the cost of building 1 school place for 550 places indicated in the collection of the CPS 81-02-03-2020.

Accordingly, using this formula, the estimated cost of building a school for 154 places using the enlarged method will amount to 278 906,96 thd. rub., which is 4% more than the construction cost determined by the consolidated estimate.

7. Conclusion
The proposed formulas, when applied in the new collections of the CPS 81-02-03-2020, will allow more accurately determining the maximum cost of construction of objects at the pre-project stage, financed from the state budget, which will avoid overstating the budget funds or lack of funds and, as a result, delays in the commissioning of objects.

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