DOI: https://doi.org/10.54338/27382656-2022.2-004

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PROBLEMS RELATED TO CREATION OF ESTIMATE AND ORGANIZATIONAL -TECHNOLOGICAL DESIGN DATABASES IN BIM

The problems related to formating of estimate and organizational-technological design simplified databases in BIM platform are considered (explored). It is proposed to combine the data necessary for estimate and organizational-technological design in one flexible system with an option of updating the information in its sub-systems by monitoring the means suggested.

Simplified formulas for calculation of costs are presented which allows us to come to certain conclusions regarding the approaches to determination of operational expenses for various construction machines and mechanisms.

Keywords: construction, machines, mechanisms, database, BIM, design, estimated cost.

Introduction

Problems of various nature arise at the spatial and geographic enlargement of design in BIM environment both in the developed and developing countries.

If the problems of 3D modeling of objects are related to the development of appropriate software, regulatory standards or the adoption of international standards, then 4D and 5D modeling requires creation of large databases, and they have many functions depending on the nature of national pricing system, local prices of materials and structures, named machines and mechanisms, etc.[1].

The key problem of automation of the estimate and organizational-technological design is associated with the following fact: design programs for architectural and engineering systems enable determining the cost of construction and materials when setting of the scope of works is a more difficult task and requires use of additional methods, often with application of "artificial intelligence" in order to choose the proper work from existing works database and to determine labor intensity or its estimated cost.

The creation of automated or, more precisely, semi-automated organizational-technological and estimate design systems in RA supposes creation of updated resource bases and adoption of resource method for determination of the construction estimate cost in construction sector, which is carried out by state funds. In private sector the calculations are made by resource method but often they are approximate and subjective.

Creation of database is useful for both sectors as determination of precise costs cannot be an obstacle for any private organization to plan its profit margin when in case of wrong calculations significant contingency expenditures may arise [2,3].

Having examined international experience, we have concluded that the "rich" countries can afford an approximate calculation - additional investment in case of unforeseen increase in costs, but in those countries making accurate calculations to plan the work and assess the risks is preferred as well [4,5,6].

Steps for pricing conceptual modernization are being undertaken in RA but they are still on stage of programming while technology develops so fast.

We think it is a task of specialists to offer electronic versions of estimate and organizational-technological design and selection of more effective one from them in order to include in common design system.

In particular, we offer the structure and content of an estimate-normative information database of construction machines, mechanisms, tools, and equipment.

Materials and Methods

We reviewed the structures and compositions of the project regulatory databases of the post-soviet republics (Russian Federation, Ukraine, Belarus, Kazakhstan), Italy, France and other developed countries. On the basis of a comparative analysis, a reform concept was developed based on international best practices, the features of the RA construction industry, the cryptographic efficiency of 4D and 5D modeling database elements in the BIM platform.

Research

The traditional structure of estimate-normative base is shown in Fig. 1. The data of all blocks needs updating but first of all the resource base must be updated and the update of one of its components ("Database of machines and mechanisms) is the main goal of this research.

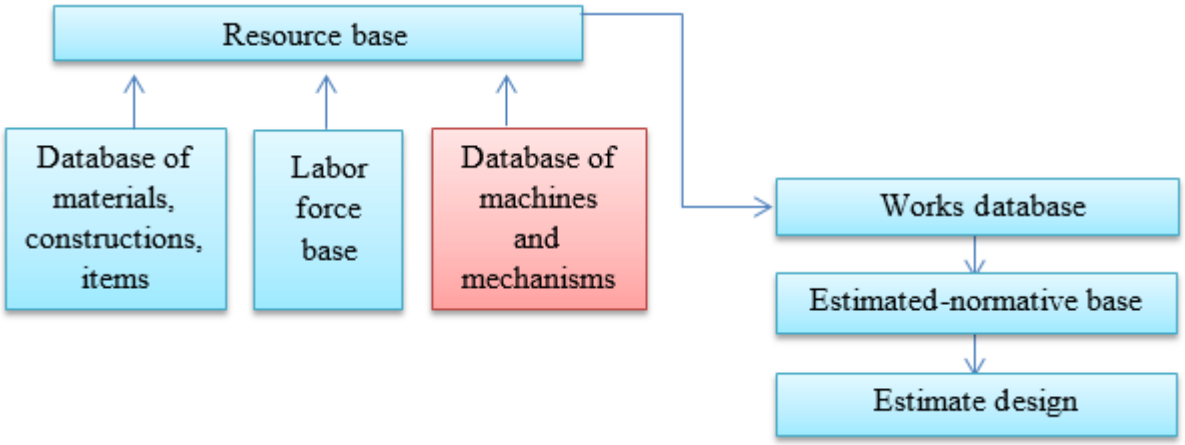

Fig. 1. *Structure of the estimate-normative base*

It is suggested to combine the estimate and organizational-technological normative bases (Fig. 2) by means of presentation of additional data in the updating database.

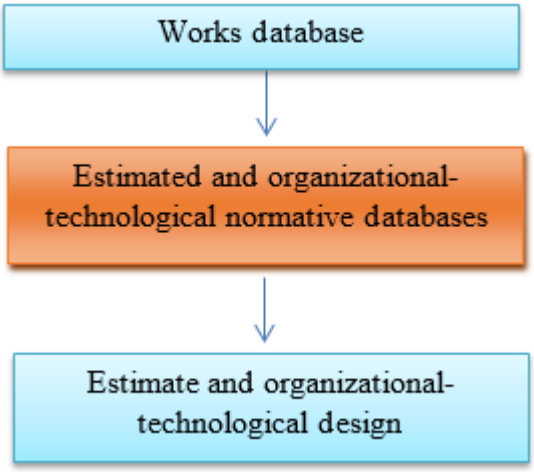

Fig. 2. *Scheme of combined estimate and organization-technological normative bases*

The electronic databases shall be as simple and attractive for use as possible, enabling automatically update of information.

The database consists of 3 sub-systems:

- master system which includes the classified codes and brands of machines, mechanisms and equipment, as well as the cost of one machine/hour (Table 1),
- technical parameters (Table 2),
- calculator of 1 machine/hour cost (Table 3).

Table 1. Master system

INFORMATION DATABASE OF ESTIMATE-NORMATIVES OF CONSTRUCTION MACHINERY, MECHANISMS, TOOLS, EQUIPMENT						
Magnified group code	**Magnified subgroup code**	**Brand code**	**Type code**	**Name**	**Brand**	**Cost of 1 machine/hour**
Types of construction equipment						
	Wheeled excavators					
01	001	001	001	Caterpillar (Cat)	M316D	
01	001	001	002	JCB	JS175W	
01	001	001	003	Komatsu	PW200-7	
	Crawler excavators					
01	001	002	001	Caterpillar (Cat)	324DL	
01	001	002	002	JCB	JS260	13948.48
01	001	002	003	Komatsu	PC300-7	
	Excavators - loaders					
01	001	003	001	Caterpillar (Cat)	428E	
01	001	003	002	JCB	4CX	
01	001	003	003	Komatsu	WB97S-5E0	

The connection between sub-systems is made by activating the links. In particular, activating the field of cost of one machine/hour the user switches to the calculation subsystem. In the calculation subsystem, the initial cost of the vehicle is transferred from the technical and value parameters subsystem, where the cost parameters are regularly updated on the basis of monitoring.

The cost of 1 machine/hour is calculated in accordance with the following logic:

The cost of operation of machines and mechanisms includes direct and indirect expenses:

$$C_{m/h} = E_d + E_{ind} + P\ , \tag{1}$$

E_{ind} – *indirect costs*: expenses that don't relate directly to the functions, products or operations of a construction project (such as costs of administrative processes and salaries for staff are indirect costs that construction companies are typically responsible for),

P – *profit,*

E_d – *direct costs.*

The direct costs in their turn consist of several components:

$$E_d = E_{dep} + E_m + E_f + E_{sm} + E_{so}\ , \tag{2}$$

E_{dep} – *depreciation costs* (the operating machines and mechanisms are subject to depreciation, the costs of acquiring machines, mechanisms and equipment are allocated by means of depreciation calculation over the periods during which their use provides certain income),

E_{sm} – *salary of maintenance personnel,*

E_{so} – *salary of operating personnel,*

E_f – *fuel expenses* (fuel expenses shall be determined on the base of certificate data of any machine of certain model),

E_m – *material costs.*

In order to simplify the calculations, the expense of materials (lubricants, repairs, maintenance parts, etc.) is determined on the basis of fuel expenses in a defined percentage, which allows updating the cost of 1 machine-hour of machine operation by monitoring the car fuel values, average wages of workers.

Table 2. Technical parameters

Code	Name	Brand	Technical parameters		
	Wheeled excavators				
01001001001	Caterpillar (Cat)	M316D	Weight	kg	17600-19800
			Bucket volume	m^3	0.4-1.3
			Engine power	kW	118
			Drilling depth	m	6.10
			Dimensions	m	8.39/2.55/3.17
01001001002	JCB	JS175W	Weight	kg	18000
			Bucket volume	m^3	0.35-0.9
			Engine power	kW	102
			Drilling depth	m	6.23
			Dimensions	m	9.1/2.5/3.01
01001001003	Komatsu	PW200-7	Weight	kg	20860
			Bucket volume	m^3	0.48-1.68
			Engine power	kW	118
			Drilling depth	m	5.40
			Dimensions	m	9.43/2.54/3.9
	Crawler excavators				
01001002001	Caterpillar (Cat)	324DL	Weight	kg	26100
			Bucket volume	m^3	0.49-1.61
			Engine power	kW	124
			Drilling depth	m	6.56
			Dimensions	m	10.6/3.39/2.98
01001002002	JCB	JS260	Weight	kg	27200
			Bucket volume	m^3	0.77-1.46
			Engine power	kW	120
			Drilling depth	m	7.23
			Dimensions	m	10.2/3.49/3.78
01001002003	Komatsu	PC300-7	Weight	kg	30800
			Bucket volume	m^3	0.52-1.4
			Engine power	kW	180
			Drilling depth	m	7.38
			Dimensions	m	11.14/3.19/3.28
	Excavators - loaders				
01001003001	Caterpillar (Cat)	428E	Weight	kg	8800
			Shovel volume	m^3	0.08-0.38
			Bucket volume	m^3	1.03
			Engine power	kW	75
			Dimensions	m	5.8/2.37/2.86
			Drilling depth/radius	m	5.3/6.64
			Unloading height	m	1.26/2.67
01001003002	JCB	4CX	Weight	kg	8660
			Shovel volume	m^3	0.04-0.48
			Bucket volume	m^3	1.10
			Engine power	kW	71.00
			Dimensions	m	5.91/2.36/3.7
			Drilling depth/radius	m	5.53/6.53
			Unloading height	m	1.17/3.21
01001003003	Komatsu	WB97S-5E0	Weight	kg	8700
			Shovel volume	m^3	0.19
			Bucket volume	m^3	1/3.9/2
			Engine power	kW	74
			Dimensions	m	5.895/2.44/3.71
			Drilling depth/radius	m	6.465/7.17
			Unloading height	m	1.21/2.84

Table 3. Calculator of the cost of 1 machine/hour

Expenditure components	Unit of measurement	Quantity	Unit cost	Total
JCB JS260				
Depreciation deductions				
Cost of the car	pc	1.000	56 180 000.000	
Depreciation deductions	hour	1.000	0.000	3612.397
Car maintenance cost				
Fuel consumption (diesel)	liter / hour	5.000	500.000	2500.000
Consumption of oils and lubricants	-	0.200	2500.000	500.000
Spare parts cost	-	0.080	28 899.177	2311.934
Builder-worker 4 category	hour	0.113	1276.550	144.250
Builder-worker 3 category	hour	0.113	1160.500	131.137
Builder-worker 2 category	hour	0.000	1055.000	0.000
Builder-worker of the 1st category	hour	0.085	949.500	80.708
Machine operating cost:				
Driver, driver - 4 categories	hour	1.000	1276.550	1276.550
Ancillary worker / builder - 1 category	hour	0.700	949.500	664.650
Total Direct Costs				**11221.625**
Overhead 13%				1458.811
Total				**12680.437**
Profit 10%				1268.044
Total				**13948.480**

At present, any system of remuneration of workers (for example, rating system) is not used in RA. Practically, differentiated approach to the specialists' remuneration is applied. For example, the high grade drivers, operators are paid 50-100% more in relation to the average salary in the field. We think, that in case we determine the estimate by input method the specialties of workers engaged in the field of construction in RA will be systemized and their qualification will be classified which allows to determine the salary of the workers engaged in maintenance and operation of machines on the basis of the coefficients defined and the average salary in the field.

Conclusion

The automation of the estimate and organizational-technological design is possible by urgent creation of resource databases, provided that those databases have to be attractive, informative, and easily updatable.

As a version an electronic database of machines, mechanisms, equipment and tools is offered which will allow obtaining data both for organization of construction process, development of works' performance designs and flow diagrams and for determination of the estimate cost for operation of machines, mechanisms, equipment and tools.

Hence, a simplified version for definition of the cost of 1 machine/hour is offered by applying average percentage ratios for calculation of value of certain components.

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Received: 18.04.2022
Revised: 06.06.2022
Accepted: 17.06.2022