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Modern Approaches of Calculating the Cost of Multicomponent Concretes Using Matrix Tools

Kuladzhi T.V.
Department of Economics and Entrepreneurship
Northern (Arctic)
Federal University
named after M.V. Lomonosov,
Arkhangelsk, Russia
kuladzhit@list.ru

Taymaskhanov Kh.E.
Department of Economic Theory
Grozny State Oil Technical University (GGNTU) named
after Acad. M.D. Millionshchikov
Grozny, Russia
asa-fenix@mail.ru

Murtazaev S.A.Yu.
Department of Materials science
Kh. Ibragimov Complex Institute of the Russian Academy of Sciences (CIRAS)
Department of Technical Sciences
Chechen Academy of Sciences
Faculty of Civil Engineering
Grozny State Oil Technical University (GGNTU) named after Acad. M.D. Millionshchikov
Grozny, Russia
s.murtazaev@mail.ru

Aliev S.A.
Faculty of Civil Engineering
Grozny State Oil Technical University (GGNTU) named after Acad. M.D. Millionshchikov
Grozny, Russia
asa-fenix@mail.ru

Khubaev M.S-M.
Faculty of Civil Engineering
Grozny State Oil Technical University (GGNTU) named after Acad. M.D. Millionshchikov
Grozny, Russia

***Abstract* – The estimation methodology of construction products cost – concretes on multicomponent binders, containing the matrix formula by Professor M.D. Kargopolov, which is recommended to be considered as a modern micro-forecasting tool for the production efficiency of construction materials and articles, allowing simultaneous calculations of their prime cost (cost) taking into account all the volumes of material costs: cement, reinforcement, components of binders, etc., as well as wage costs, depreciation etc. The calculation technique using the matrix formula allows visualization of all value figures of both the concrete outputs elements: complex binders for the concrete composites manufacture and other materials, and the cost of final goods – reinforced concrete slabs. Calculations using the matrix formula by Professor M.D. Kargopolov are recommended for calculating the cost indicators of innovative construction products.**

Keywords – concretes on multicomponent binders; the helium heat treating; micro-forecasting tools for efficiency production; composite construction materials; the matrix formula by Professor M.D. Kargopolov.

I. INTRODUCTION

In the civil engineering complex of Russia at the State level, measures are being taken to enhance the effectiveness and improve the system of determining the construction products cost. The estimated cost of civil engineering works includes: direct costs, overhead costs and profit of payments. In accordance with art 1, p. 743 "Technical documentation and estimates" of The Russian Civil Code [1], the contractor is responsible for civil engineering works "in accordance with the technical documentation determining the scope, content of work and other requirements, and with the estimate determining the price of works". According to the "GDC 81-35.2004. Methodology of determining the cost of construction products in the Russian Federation territory" [2], the estimated cost of construction is the sum of money for construction in accordance with the project and the basis for determining the capital investments, construction financing, formation of agreed contract prices for construction products, payments for contractual (building and assembly, repair and construction, etc.) works performed to recover all costs foreseen in the Summary Cost Estimate.

To ensure the effectiveness of the innovative products production in the practice of economic calculations, the use of the matrix formula by Professor M.D. Kargopolov is recommended. The formula ensures transparency and accuracy of calculations of the production prime cost, taking into account all territorial conditions affecting the estimated cost of production [23–25, etc.].

Matrix tools developed by M.D. Kargopolov, on the basis of the strict interrelationship between costs and output, provides for an inter-operational balance of costs and results of production in any organizational structure [5-7, etc.]. Similar to the approach built into the "input-output" balance methods by V.V. Leontiev between production and consumption of products at the macro-level – national and international levels, the matrix formula by Professor M.D. Kargopolov in economic calculations, is recommended to use as a tool for predicting production efficiency at the micro-level of organizations, that is, to consider it as a modern micro-forecasting tool for production efficiency in organizations of various legal forms (OAO, OOO, etc.).

II. METHODS AND MATERIALS

As noted in [26], the civil engineering complex consists of a number of independent economic entities, including, according to the resource principle: enterprises of the "construction" and "industry of construction materials", as well as sub-sectors providing construction with inputs, equipments and services, and according to the target principle: enterprises of the construction and industry of construction materials, as well as engineering and research enterprises, the education establishments of civil engineering, logistics of constructions.

Doctor of Science, Economics M.D. Kargopolov showed in [6-8] that any economic system of commercial entities can be represented as a scheme of interacting objects that produce a specific **output** (as part of X). A part of this **outputs** (W) is used inside the studied economic system, and the other part (Y) is displayed outside this system as the final **output**. In connection with this, to assess the cost value and results of the effectiveness of each product, the manufacturing process (P) of the organization (see Fig. 1) can be represented by a general structure.

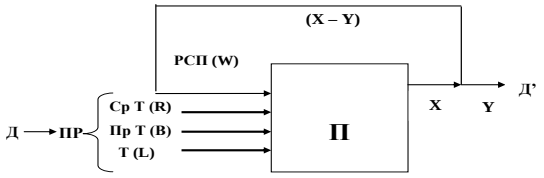

Fig. 1. Scheme of transformation of production resources into commercial output in the manufacturing process.

The scheme in fig. 1. follows that the primary resources (PR) must be purchased at wholesale-purchasing or market prices for money (M), and the sale of manufactured commercial output (Y) on the market for the company will bring new money (M'). For profit-making organizations (enterprises) always M' > M. Then the difference between: X – Y = W (OPS) indicates the **outputs** (W) of the economic entity that will be used for domestic production consumption and, thus, considered as the cost of own production resources (OPS) for technological and (or) intrafactory turnover. In connection with this, as opposed to the primary resources, the cost of the OPS entity is always the calculated value of the prime cost (or total cost) of the production of each unit of OPS **outputs** (works, services).

The Matrix formula by professor M.D. Kargopolova has the form [8]:

$$P = \left(E - A^T\right)^{-1} \cdot D^T \cdot C \qquad (1)$$

where: P = ||pj||; j = $\overline{1,n}$ – is the desired column-vector of the production (total**)** prime cost of an entity of output production (works, services);

E – identity matrix n x n;

A = ||aij||, i = $\overline{1,n}$, j = $\overline{1,n}$ – matrix n x n of consumption rates of own production resources;

D = ||dij||, i ∈ L U R, j = $\overline{1,n}$ – matrix of consumption rates of primary resources (L - variables, R - constant),

T – the transposition mark for matrices A and D.

C = ||ci||, i ∈ L U R – primary resources wholesale-purchasing prices column-vector. If in matrix D resources are represented by value indicators, then in matrix C these resources, respectively, should be denoted by the number - 1 (one).

To calculate the matrix formula by Professor M.D. Kargopolov the prime costs of one entity of output, all cost items must be divided into two groups: cost items of own production resources and cost items of primary resources. Under these circumstance, in the cost items of primary resources it is necessary to distinguish variables (L - types) and constant (R - types) costs, in which the variable costs (dlj) rates of use do not depend on production volumes, and the constant costs (drj) rates of use depend on production volumes. In connection with this, taking into account the actual (or standard) output production (works, costs), a relevant recalculation of costs per entity of output should be putted into action.

III. RESULTS

In both cases, to calculate the total prime cost of reinforced concrete slabs and helioforms production, the data on labor costs and material consumption for the manufacture of reinforced concrete slabs from floor slab 10-60.12 were used under the terms of the State Unitary Enterprise *Argentine Concrete Products and Fabrics plant*, made in [5 in Table. .3.6 - 3.11] according to [28, Table 5.4 - 5.8 and Appendix 1].

That way, Table 1 presents the matrix A (size 8x8), and Table 2 presents the matrix P.

TABLE I. RATE OF RESOURCE USE MATRIX A (8 × 8)

Water	**Steam**	**Binder Compounds**		**Dry Concrete Mix**		**Reinforced Concrete Outputs With The Helium Heat Treating**	
		CB 100	***CBF 50***	***CB 100***	***CBF 50***	***CB 100***	***CBF 50***
0	1	0	0	0	0	0,14	0,152
0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	0
0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

[a.] CB - COMPLEX BINDING

[b.] CBF - COMPLEX BINDING FILLERS

In table 3 the matrix D is composed in such a way that it consistently (from simple to complex products - reinforced concrete slabs) reveals the consumption of materials for:

- industrial water production: column 1;
- steam production: column 2;
- production of complex binders (CB) (dry pack: cement, filler and additives *Bio-HM*), made in the scientific laboratory of the Civil Engineering Faculty in GGNTU [28]: columns 3, 4;
- production of chuted concrete components (dry pack: complex binders (CB) and stone screening dust): columns 5 - 6;
- production of 1 m^3 of concrete outputs in the helium heat treating: columns 7-8.

In tables 1-4, taking into account the data in [5. P.248-262], the results of calculations index according to the matrix formula by Professor M.D. Kargopolov are showed.

TABLE II. MATRIX P - ESTIMATED COST, RUB '000/ UOM

№	Name Of Components And Reinforced Concrete Outputs		RUB '000/ UOM
1	Water		0,08043
2	Steam		0,24853
3	Binder Compounds	CB 100	2,72
4		CBF 50	1,76276
5	Dry Concrete Mix	CB 100	3,095
6		CBF 50	2,14376
7	Reinforced Concrete Outputs With The Helium Heat Treating	CB 100	4,77774
8		CBF 50	3,82747

The calculations of matrix P (Table 2) found that all indexes of the total prime costs of 8-types outputs are obtained. Their absolute values differ from similar data index, which are given in [28], to 0.2% due to clarification of the estimated cost of steam and taken to be calculated: 279.4 RUB/m^3 in [5, tab. 3,8], instead of 303.3 RUB / m^3 according to [28, Table. 5,4].

TABLE III. MATRIX D OF CONSUMPTION RATES OF PRIMARY RESOURCES, INCL. PURCHASED FOR REINFORCED CONCRETE OUTPUTS PRODUCTION

Name Of Expenditure	Water	Steam	Binder Compounds		Dry Concrete Mix		Reinforced Concrete Outputs With The Helium Heat Treating	
			CB 100	*CBF 50*	*CB 100*	*CBF 50*	*CB 100*	*CBF 50*
Capital investments in helioforms (per 1 m^3 of reinforced concrete products), RUB '000/ m^3	0	0	0	0	0	0	0,012	0,012
Cement, RUB '000/ ton	0	0	0,5	0,254	0	0	0	0
Stone screening dust, RUB '000/ ton	0	0	0	0	1,5	1,524	0	0
Filler, RUB '000/ ton	0	0	0	0,254	0	0	0	0
Additives Bio-HM, RUB '000/ ton	0	0	0,01	0,00508	0	0	0	0
ReinforcementRUB '000/ton	0	0	0	0	0	0	0,065	0,065
Electricity and fuel	0,0124	0,0414	0	0	0	0	0,2794	0,2794
Water, RUB '000/ ton	0,02365	0	0	0	0	0	0	0
Wage, RUB '000	0,01	0,025	0	0	0	0	0,3439	0,3439
Equipment maintenance costs (127.8% of salary), RUB '000	0,0128	0,032	0	0	0	0	0,4395	0,4395
Shop expenses (25% of salary), RUB '000	0,0025	0,0064	0	0	0	0	0,086	0,086
Social insurance charge (34% for 2011), RUB '000	0,0034	0,0085	0	0	0	0	0,1169	0,1169
Works general expenses (20 %), RUB '000	0,002	0,005	0	0	0	0	0,06878	0,06878
Other, RUB '000	0,0137	0,05	0	0	0	0	0	0

[c.] * For comparison with the data of the paper [28], 34% of salary was saved (till 2011).

TABLE IV. MATRIX C OF PRIMARY RESOURCES WHOLESALE-PURCHASING PRICES

№ п/п	Name Of Expenditure	Price
1	Capital investments in helioforms (per 1 m3 of reinforced concrete products), RUB '000/ m3	0,012
2	Cement, RUB '000/ ton	5
	Stone screening dust, RUB '000/ ton	0,25
2	Filler, RUB '000/ ton	1,5
4	Additives Bio-HM, RUB '000/ ton	22
5	Reinforcement, RUB '000/ ton	5
6	Electricity and fuel	1**
7	Water, RUB '000/ ton	1
8	Wage, RUB '000	1**
9	Equipment maintenance costs (127.8% of salary), RUB '000	1**
10	Shop expenses (25% of salary), RUB '000	1**
11	Social insurance charge (34% for 2011*), RUB '000	1**
12	Works general expenses (20 %), RUB '000	1**
13	Other, RUB '000	1**

[d.] ** The number 1 (one) in matrix C indicates resources that in matrix D have a numerical value (ref. matrix D).

It should be borne in mind that economic methodology performs instrumental and reflexive functions, where the first is "the role of an economic research instrument," and the second is reflections "on how to achieve" the goals set" [31-37].

IV. CONCLUSION

To predict the costs indexes of innovative construction outputs, the use of the matrix formula by Professor M.D. Kargopolov is recommended. The formula simultaneously and with absolute accuracy allows us to determine all the products costs indexes, taking into account the various local conditions of their production.

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