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MANAŽMENT KOMPLEXNÝCH ŠTRUKTÚROVANÝCH ZDROJOV V INŽINIERSTVE A STAVEBNÍCTVE

COMPLEX-STRUCTURE RESOURCE MANAGEMENT IN ENGINEERING AND CONSTRUCTION

Originálny problém riešený v tomto článku je model analyzovania hierarchicky štruktúrovaných zdrojov zabezpečujúci riadenie dostupnosti a využiteľnosti zdrojov v alokovaných jednotkách komplexnej štruktúry pre určené práce. Tento model je aplikovateľný pri návrhu rozhodovacích systémov v plánovaní vojenských a inžinierskych operácií. Hodnotenie jednotiek takýchto štruktúr s využitím počítačov vyžaduje vziať do úvahy skutočnosť vzájomného ovplyvňovania jednotiek. Okrem metódy hodnotenia komplexných zdrojov sa v práci formuluje i model rozmiestnenia hierarchickej štruktúry pre práce na oddelených pracovných frontoch. Model umožňuje automatizáciu výpočtov založenú na navrhnutí kontraktora pre súbor činností vykonávaných na pracovných frontoch, ktoré majú základ v ich spotrebe práce vztiahnutej na zdroje na akejkoľvek úrovni hierarchickej štruktúry.

The original issue solved in this article is the model of analyzing hierarchical-structure resources ensuring controlling the availability and engagement of the resources in allocating units of a complex structure for given works. This model is applicable when designing the decision facilitation systems in planning military and engineer operations. "Qualifying" the units of such structures using the computer requires taking under consideration the fact of units "nesting" in others. Apart from the method of "qualifying" complex resources, in this work has been formulated a model of allocating a hierarchical structure for works on the separated work fronts. The model enables an automation of calculations aimed at designating the contractor for the set of tasks executed on work fronts, based on their labor consumption referred to the resources of any of the levels of a hierarchical structure.

1. Introduction

Engineer and construction operations consist in executing works of varied character and scope in various locations (fig. 1) and in different technological and time conditions. Such operations should be related to a specific organizational unit which has means of work – resources – in its structure. Whenever considering here engineer and construction operations, we mean specific material operations carried out by a specific contractor with a known resource potential and a defined plan of executing the contracted tasks. This is not the execution of a single project but participation in the realizing of numerous projects (fig. 1). The contractor considers these projects as work fronts to which he is obliged to allocate adequate labor forces (resources) in the time required by the organizers of those projects, in order to carry out the tasks allocated to him.

Resource allocation management is one of the main problems in production planning in a construction company. It is also a decision-making task in planning the operations of military engineer sections and engineer rescue units. The type of operation in both these organizational structures is very similar, despite certain differences in their resource structures because these units carry out works that have a common designation as engineer and construction works.

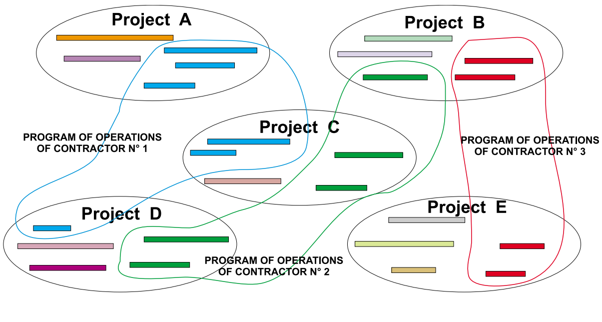

Fig. 1. Diagram of the interdependence of contractors' projects and production schedules in engineering and construction.

Resources can be organized into various complex structures. In essence, when analyzing the character of a structure, one can distinguish their two types:

- hierarchical (e.g. of military type),
- additive organizational units.

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Additive units can be specialized or comprehensive. Specialized units do not compete with one another in task realization, however, comprehensive ones can seek to carry out specific tasks (shared by them), so there is a decision making problem here when allocating tasks.

Hierarchical-structure resource management is relatively difficult. Such structures can be found not only in the military but also in rescue units. Based on their pattern are also created militarized units, engineer sections in case of flooding and other natural disasters. When directing their operations it is required to examine possibilities of realizing tasks through an analysis of resources at their disposal in a specific part of the contractor's hierarchical structure. This is not an easy task, since most often it is not known which of the parts of the hierarchical structure (which of the subunits of the given structure) is able to realize the considered tasks. The situation becomes even more complicated when it must be remembered that some of these subunits have already been assigned and are already engaged. Thus there is a need to devise a method of analyzing the hierarchical-structure subunits' availability and examining the production potential of their chosen subset. This particular problem is the subject of this article.

The problem of hierarchical-structure resource management in planning has been undertaken to a marginal degree, i.e. in studies [1, 2, and 3]. Similarly, only very few programs for planning projects offer a possibility of analyzing complex-structure resources (i. e. PERTMASTER, TEAMPLAN). In these programs such a structure is analyzed only in one direction – from top to bottom of the resource-hierarchy tree. This results in a situation that allocating a complex unit to carry out a given task entails information about the unavailability of all subunits of the resources at the disposal of the appointed unit. This, however, does not affect the state of possession of the master units. Let us illustrate this problem with a simple example.

Let us assume that the resource-hierarchical structure is a sappers' battalion (sapb) consisting of two sappers' companies (sapc), a mining and demolition platoon (mnpl), a commanding platoon (compl), and a supplies platoon (suppl). Each of the sappers' companies consists of two sappers' platoons (sappl). Let us assume that we have one such battalion at our disposal. If we appoint for specific tasks one sapc and one sappl, the state of possessions turns into the following scheme: two sappl, mnpl, plcom, suppl, so:

$$\{sapb = \{2 \times \{sapc = 3 \times \{sapg\}\}, \{mnpl\}, \{compl\}, \{suppl\}\}\} -$$
$$- \{sapc\}, \{sapg\}\} = \{mnpl\}, \{compl\}, \{compl|, 2 \times \{sappl\}\}$$

No longer do we have at our disposal a sappers' battalion and the second sappers' company because these units are characterized by an incomplete structure. The computer program, on the other hand, provides us with the information that we still have one sappers' company and sappers' battalion at our disposal, which is, of course, wrong. This is why a resource-structure model and a method of analyzing it are needed in order to devise a numerical method of hierarchical resource management.

2. Formulating the problem

The subjects of this analysis are the problems of active resource allocation for realizing engineer and construction tasks on specific work fronts. Each project comprises a few (or more) work fronts, whereas the work front itself constitutes a defined set of tasks. The resources are organized as a contractor's hierarchical structure (of military type). The essence of planning problem solving is establishing contractors for works on each of the work fronts who are able to carry out the tasks assigned to them in the required timeframe. By this is meant a "transposition" of the project contractor's structure parts onto the sets of works constituting work fronts. At the same time, the contractor's standard functional arrangement should be maintained (without excessively distorting his structure) as well as a time-effective works realization on each of the work fronts should be planned. The realization of such tasks poses certain problems because the contractors' structures are not separately designed for each of the investment tasks.

Allocation of hierarchical-structure contractors to work fronts requires a slightly different approach to examination of the availability of resources, which are here in the structure of mutual dependence. Resource allocation (of a given organizational unit) of a higher level results in diminishing the amount of available resources on lower levels. On the other hand, allocating units of lower level resources as subresource of a higher organizational unit ensues diminishing of the realization potential of a higher organizational unit.

In analyses that follow the sequential interdependence of tasks will be omitted. Incomplete use of realization means caused by limitations of the sequential (in series) work realization, will be taken into consideration using adequate coefficients. This is because the aim of this article is not to prepare a schedule of works realization but only to devise a decision as to allocating forces and means to works on certain work fronts which are able to execute them in the accepted time.

3. Model of the contractor's projects

It is assumed here that for executing engineer and construction tasks we are managing a set of active resources $R = \{r_1, r_2, ..., r_k, ..., r_z\}$ (k – the number of resource) whose parts can create a hierarchical structure determined by adjacency matrix (see example in fig. 2):

$$P = [p_{sk}]_{z\ x\ z},$$

in which p_{sk} – determines the number of resource units $r_k \in R$ in resource unit $r_s \in R$.

In matrix P one can distinguish:

- Subset R' comprising main resources which are not a component of other resources (for these resources $p_{sk} = 0$ for $s = 1, 2, \ldots, z$);

- Elementary resources – subset R'' – which do not have in their structure any other resources (for these resources $p_{sk} = 0$ for $k = 1, 2, \ldots, z$);
- Other resources that are intermediate organizational units.

When interpreting the above described notation, one can assume that as elementary resources are most often understood specific machines, or soldiers, workers possessing concrete qualifications, while main resources are independent teams, units or other unitary resources which are not included in any other organizational structures. We assume here that the main resources are unitary resources (they appear in singular quantities). In order to simplify the notation, let us assume here that matrix P is arranged topologically and that g of the first resources is identified as the main resources.

$P =$

R	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}
r_1	0	0	2	2	1	0	2	0	0	0
r_2	0	0	0	0	1	2	0	0	0	2
r_3	0	0	0	0	0	0	1	2	0	0
r_4	0	0	0	0	0	0	2	1	0	0
r_5	0	0	0	0	0	0	0	1	1	1
r_6	0	0	0	0	0	0	0	0	1	2
r_7	0	0	0	0	0	0	0	0	0	0
r_8	0	0	0	0	0	0	0	0	0	0
r_9	0	0	0	0	0	0	0	0	0	0
r_{10}	0	0	0	0	0	0	0	0	0	0

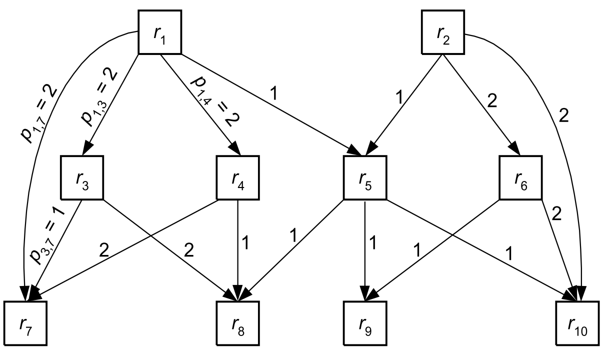

Fig. 2. Exemplary graph describing the contractor's hierarchical structure and its matrix representation

The resources are in a situation described by the dynamics of the operations. This means that certain units are unavailable in given time intervals. In order to identify this unavailability we assume that the state of the resources at our disposal will be determined by the matrix of the availability of resources in the time scale: $D = [d_{kt}]_{z\ x\ H}$ whose parts dkt determine the additive figures of the resources available in time unit $t = 1, 2, \ldots, H$; where H – determines the horizon of planning time. Such characteristics can be defined by time intervals in which the availability of resources is the same.

Through an analysis of matrixes P and D the availability of all resources in time can be determined:

$$z_{kt} = d_{kt} \qquad \text{for} \quad k = 1, 2, \ldots, g$$
$$z_{kt} = d_{kt} + \sum_{t=1}^{k-1} p_{ik} \cdot z_{it} \qquad \text{for} \quad k = g+1, g+2, \ldots, z \qquad (1)$$

Of course, matrix Z does not determine the state of possessions of the contractor, as the resources of set R are not additive, so the number of slave structures is a function of the number of master units and their complexity. Appointing a certain unit from set R to realize tasks diminishes the state of the contractor's flexibility not only by this unit but also by the resources which belong to the structure of the appointed unit.

The potential can be unambiguously determined by additive resource units which are the elementary resources (set R''). One can determine it according to the formula:

$$M_k^d = \sum_{t=1}^{H} Z_{kt} \quad \text{for} \quad k : r_k \in R'' \qquad (2)$$

This quantity can also be referred to the contractor's organizational units if they are treated as additive means of executing the operation.

4. Description of the structure and scope of the analyzed operations

We assume that we will be solving here the problem of allocating parts of the contractor's hierarchical structure onto the work fronts. The work front is, as in [4], a teritorially designated set of works, and in an exceptional case it can be a single task.

The names of work fronts always create set $F = \{f_1, f_2, \ldots, f_j, \ldots, f_m\}$ (j – determines the number of work front), and the names of tasks create set $O = \{o_1, o_2, \ldots, o_i, \ldots, o_n\}$ (i – the number of task).

Tasks (parts of set O) are elementary calculation units in planning oprations. They are constituted by works determined in detail which have to be carried out within a particular task, according to the prescribed realization technology. In each task for one quantity survey unit is determined specific input which has to be spent so that the task can be carried out. Therefore, these are standards which in [3] are determined by matrix $N = [n_{ik}]_{n\ x\ z}$, where nik determines the amount of resource input $k : r_k \in R$ for realizing task i: $o_i \in O$.

The scope of set O is determined by the planner. According to the needs and conditions of realization, the planner decides on the technology of task realization and carries out the quantity survey of work fronts, and at the same time, specifies the number of tasks (in relevant quantity survey units) to be carried out on each of the work fronts. So, matrix $K = [k_{ij}]_{mxn}$ is known, in which k_{ij} determines the number of partial tasks i: $o_i \in O$ to be carried out within work front j: $f_j \in F$; as well as matrix $W = [w_{kj}]_{z\,x\,m}$, whose parts determine the labor consumption of work fronts and are determined according to the formula:

$$w_{kj} = \sum_{i=1}^{n} n_{jk} \cdot k_{ji} \qquad (3)$$

Work fronts are characterized by realization deadlines (from – to) determined by instructions. By marking these intervals with variables $\langle e_j^s; e_j^f \rangle$ where j: $f_j \in F$, can be determined the necessary amount of resources which has to be directed to work fronts, so that the works on these fronts can be carried out within the deadlines determined by instructions:

$$\Psi_{kj} = \frac{w_{kj}}{\alpha_k} \cdot \frac{1}{e_j^f - e_j^s} \quad (k = 1, 2, ..., z; j = 1, 2, ..., m), \qquad (4)$$

where: $\alpha_k \in (0, 1\rangle$ – is the coefficient determining the evaluation of the scope of consumption of work time by the k-th resource.

Vectors Ψ_{kj} for particular work fronts $j = 1, 2, ..., m$ determine the amounts of additive resources which have to be directed onto these work fronts. We remember that the resources constitute a complex structure. For comparison they should be reduced to execution potential (in this case – the required one) referred to the set of elementary resources. So, we calculate the number of parts of the structure of resources in the set of additive resources determined by matrix Ψ:

$$\begin{aligned} \Psi'_{kj} &= \Psi_{kj} && \text{for} \quad k = 1, 2, ..., g \\ \Psi'_{kj} &= \Psi_{kj} + \sum_{i=1}^{k-1} p_{ik} \cdot \Psi_{ij} && \text{for} \quad k = g + 1, g + 2, ..., z; \end{aligned} \qquad (5)$$

and next we calculate the required contractor's potential for each of the work fronts $j = 1, 2, ..., m$:

$$M_k^w = \Psi'_{kj} \cdot (e_j^s - e_j^f) \qquad \text{for} \quad k : r_k \in R''. \qquad (6)$$

5. Formulating the decision-making problem

The decision-making problem consists in determining the resources (the type and amount) which have to be directed onto particular work fronts. The solution is achieved by way of "associating" the availability of resources determined by matrix Z with the requirements of the work fronts described by the relations (4)-(6). At the same time we want to maintain the standard organizational arrangement of the resources without disrupting their structures, if possible.

In the language of mathematical programming, with the above determined data, the problem of appointing the resources which have to be directed onto the given work fronts, so that the works on them are carried out within the deadlines determined by instructions, can be formulated as follows:

⇒ Determine decisional variables:

$$X = [x_{kj}]_{z\,x\,m},$$

where $x_{kj} \in C_+$ determines the amount of additive resources k: $r_k \in R$ directed to execute works on the j-th work front;

⇒ so that the following conditions can be met:

- Resource availability in each time unit $t = 1, 2, ..., H$:

$$\begin{aligned} &\sum_{j=1}^{m} l_{jt} \cdot x_{kj} \le z_{kt} && \text{for} \quad k = 1, 2, ..., g \\ &\sum_{j=1}^{m} l_{jt} \cdot x_{kj} + \sum_{i=1}^{k-1} \left[p_{ik} \cdot \sum_{j=1}^{m} l_{jt} \cdot x_{ij} \right] \le z_{kt} \\ &\text{for} \quad k = g + 1, g + 2, ..., z, \end{aligned} \qquad (7)$$

where l_{jt} – availability vector of the j-th work front in the time scale;

$$l_{jt} = \begin{cases} 1 - \text{if } t \in \langle e_j^s, e_j^f \rangle \\ 0 - \text{in another case} \end{cases};$$

- The requirements of work fronts $j = 1, 2, ..., m$ referring to the execution potential:

$$\begin{aligned} &x_{kj} \ge \Psi'_{kj} && \text{for} \quad k = 1, 2, ..., g \\ &x_{kj} + \sum_{i=1}^{k-1} x_{ij} \cdot p_{ik} \ge \Psi'_{kj} && \text{for} \quad k = g + 1, g + 2, ..., z. \end{aligned} \qquad (8)$$

The potential of forces directed onto work fronts can be determined in a similar way as the needs of the fronts. So, we calculate the numbers of the parts of the resource structure in the set of additive resources determined by matrix X:

$$\begin{aligned} x'_{kj} &= x_{kj} && \text{for} \quad k = 1, 2, ..., g \\ x'_{kj} &= x_{kj} + \sum_{i=1}^{k-1} p_{ik} \cdot x_{ij} && \text{for} \quad k = g + 1, g + 2, ..., z, \end{aligned} \qquad (9)$$

and next the potential of the directed forces for each work front $j = 1, 2, ..., m$:

$$M_{kj}^x = x'_{kj} \cdot (e_j^f - e_j^s) \qquad \text{for} \quad k : r_k \in R'' \qquad (10)$$

A complex structure of resources requires examining if the structure X appointed for the given work front matches the needs of the work front. The point here is to determine a systematical index of work fronts enabling assessment of the allocation of forces for executing works on fronts. Such an index should be constituted by the cost of surplus resources, that is which have been allocated over the required work fronts potential. The cost can be determined according to the following relation:

$$K = \sum_{j=1}^{m} \sum_{k \in R} [c_k \cdot (M_{kj}^x - M_{kj}^w)], \qquad (11)$$

where c_k – the cost of outage (non-usage) of elementary resources ($k \in R''$) per time unit.

There may be different criteria for evaluating the resource allocation for the work fronts. Aiming at possibly clear-cut assignment of the contractor to the particular work front, thus assigning a resource unit which in its structure has necessary means for executing works on a given work front, we minimize the total amount of the assigned resources:

$$\min \varphi : \varphi = \sum_{k=1}^{z} \sum_{j=1}^{m} x_{kj} - \varepsilon \cdot k \tag{12}$$

where: $\varepsilon\, k$ – product giving preference to the parts of the resource structure which are the lowest in the hierarchy (we assume that ε – is a sufficiently small coefficient and matrix P is arranged topologically).

Criterion (12) prevents a dispersion of the resource structure when dividing the resources between the work fronts. Aiming at minimizing the amount of the allocated resources, comprehensive contractors should be sought for the work fronts, if possible. This, however, results in surplus solutions. This is why it is necessary to add to a thus formulated criterion the second one, minimizing the costs of surplus resources according to formula (11). Only a joint analysis of these criteria gives effects accepted by the decision-makers.

The cost criterion, however, should be formulated as the function of the decision variable x_{kj} ($k = 1, 2, ..., z; j = 1, 2, ..., m$). In this way, using the relation (9), this criterion can be formulated as follows:

$$\min K:\; K = \sum_{j=1}^{m} \left\{ (e_j^f - e_j^s) \cdot \sum_{k \in R} [c^k \cdot (x'_{kj} - \Psi'_{kj})] \right\}. \tag{13}$$

The formulated model of the decision-making problem is fairly difficult to solve using the known operational examination algorithms. Yet, formally, it designates the description of the decisions, limitations and the objectives to be met. The demonstrated mathematical relations enable an automation of calculations, and after their adequate transformation to a model with a one-index decision variable, one can use the methods of linear programming for finding a solution enabling an optimal allocation of the resources between the work fronts. An example of such a task for a structure of resources determined in fig. 2 is demonstrated below.

6. Example of the allocation of a hierarchical resource structure onto work fronts

Let us assume that we will be solving a problem of allocating the resources of the contractor whose state of possessions of additive resources in the whole of the considered time horizon is the same. This state is determined by vector D (tab. 1). Using relation (1) was determined the number of each of the parts of the resource structure at the contractor's disposal. These numbers are determined by vector Z (tab. 1). For the resources were also determined the usage coefficients $\alpha_k \in \langle 0, 1\rangle$ and the costs of the outage of the elementary resources $c_k = 1$ for ($k = 7, 8, 9, 10$), so the resources will be counterbalanced.

Next, we will conduct an allocation of the above determined resources onto three work fronts, whose labor consumption and the realization deadlines determined by instructions are shown in table 2. Using relations (4) and (5), were determined the essential resources which have to be directed onto the considered fronts (tab. 3).

State of the contractor's resources (data referring to the resources) — Table 1

Data designation	Main resources		Intermediate resources				Elementary resources			
R	r_1	r_2	r_3	r_4	r_5	r_6	$\mathbf{r_7}$	$\mathbf{r_8}$	$\mathbf{r_9}$	$\mathbf{r_{10}}$
D	1	1			2					
Z	1	1	2	2	4	2	**8**	**10**	**6**	**10**
α	0.6	0.6	0.7	0.7	0.7	0.7	**0.8**	**0.9**	**0.9**	**0.8**
C							**1**	**1**	**1**	**1**

Labor consumption of the considered work fronts and the realization deadlines determined by instructions — Table 2

Work fronts	Labor consumption of the resources – matrix W										Deadlines	
	r_1	r_2	r_3	r_4	r_5	r_6	R_7	r_8	r_9	r_{10}	e^s	e^f
f_1					4.5			6.8			0	3
f_2							7.4	6.8			1	3
f_3					2.57	2			1.2		3	5

Essential resources for executing works on work fronts — Table 3

Designations		r_1	r_2	r_3	r_4	r_5	r_6	$\mathbf{r_7}$	$\mathbf{r_8}$	$\mathbf{r_9}$	$\mathbf{r_{10}}$
Ψ	f_1					2.143			2.519		
	f_2							4.625	3.778		
	f_3					1.836	1.429			0.667	
Ψ'	f_1					2.143			**4.661**	**2.143**	**2.143**
	f_2							**4.625**	**3.778**		
	f_3					1.836	1.429		**1.836**	**3.931**	**4.693**

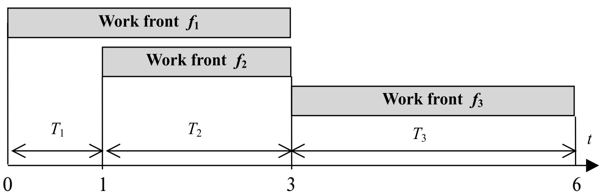

Fig. 3. Schedule representation of works execution on the considered work fronts

The deadlines of availability of the work fronts allow to define three time periods whose resource requirements are different (fig. 3). Because we assume that the resource allocation on the work fronts is constant in the entire time interval of works execution on the work front, it is enough to examine the availability of the resources in the second and third time interval (resource limitations for the first time interval are met if the resource availability limitations for the second one are met).

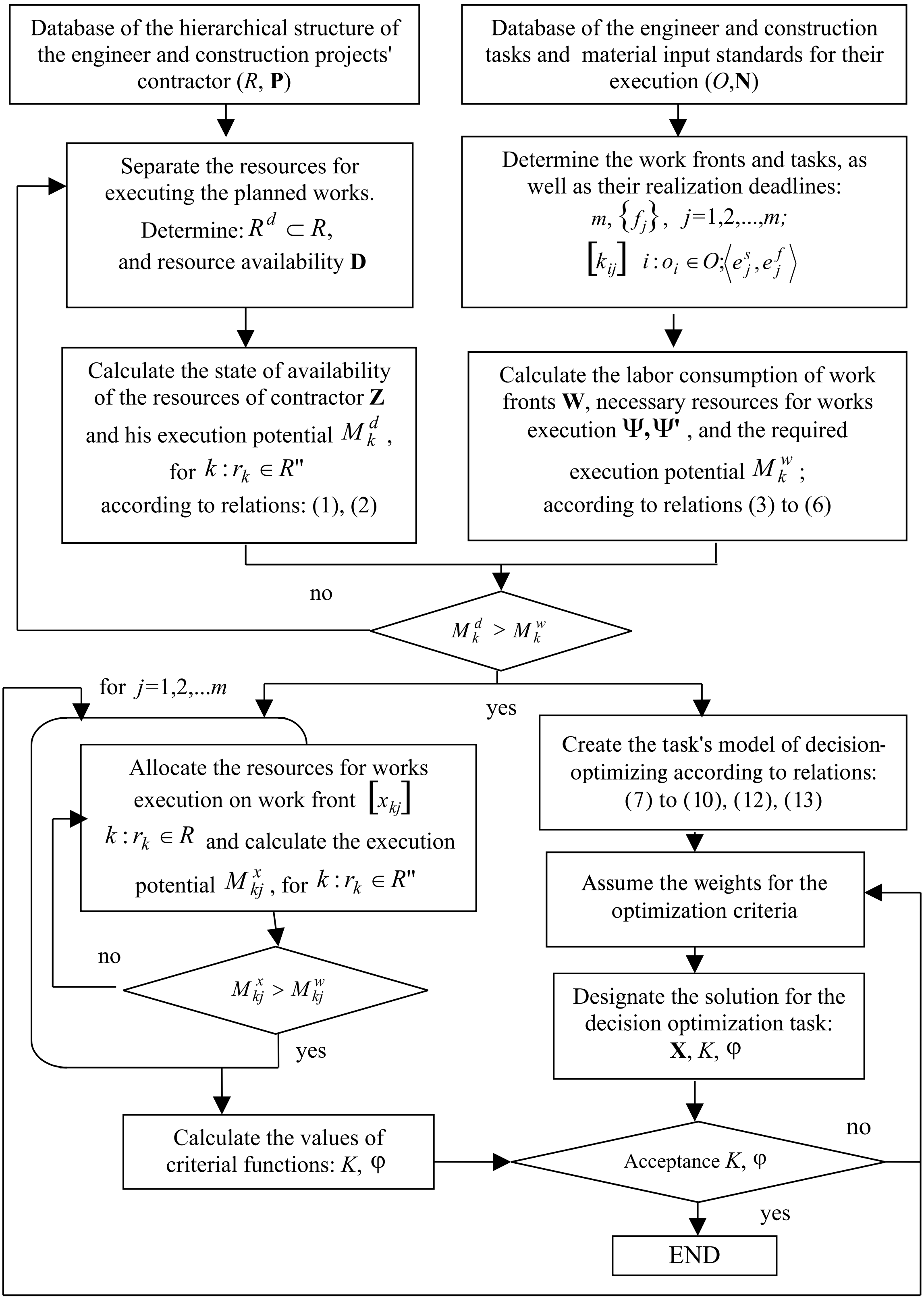

Fig. 4. Block diagram of the SFD allocation of the hierarchical-structure contractors for works execution on work fronts

Allocated resources for works execution on work fronts Table 4

Designations		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}
	f_1					3			2		
X	f_2			2	2						
	f_3					2	2				
	f_1					3			**5**	**3**	**3**
X'	f_2			2	2			**6**	**6**		
	f_3					2	2		**2**	**4**	**6**

In the solution it was decided that the work fronts will be directed onto 13 organizational units ($\varphi = 13$), whose type and number is determined by matrix X in tab. 4. In this table is also shown the set size of the parts of the resource structure (matrix X') in the directed organizational units. The cost of the resources surplus-allocated will be:

$$K = c_7 \cdot 1.375 + c_8 \cdot 2.725 + c_9 \cdot 0.926 + c_{10} \cdot 2.164 = 7.19$$

A comparison of tables 3 and 4 allows one to decide if the force allocation is correct. The amount of the allocated elementary resources (in gray spaces) outweighs the needs of these resources for each of the work fronts. These amounts, added for the work fronts executed parallelly, do not exceed the state of possessions determined by vector Z.

7. Concept of the computer implementation

The problem of allocating the contractors of hierarchical structures for works execution on work fronts is one of the crucial elements of operative planning. For such planning are created decision-making models, which should constitute the foundation of building the systems of facilitating decisions (SFD). A schematic diagram of SFD is presented in fig. 4. The essence of this system is two approaches to solving the problem of resource allocation:

- first – optimizing – by creating and solving a linear model,
- second – intuitive, “manual” – by allocating the resources for works execution on the analyzed work fronts conducted by the user of the computer system.

The first approach may satisfy the decision-maker with its results because of the highly polarized formulas of the target function. Because of this reason there must exist a way of verifying the optimizing model, or even rejecting the optimization of the decision, and taking a heuristic decision. The computer should facilitate the user in this process as to controlling the resource availability in time scale, the assessment of the labor consumption of the work fronts for each of the resources, as well as evaluating the potential of the resources directed onto each of the work fronts. The presented formulas of the decision-making model can be used for this end.

The issue of directing the hierarchical structure resources is an important component of automating planning in the military. The material input for works execution can be related not only to elementary resources but also to the organizational structures located on any of the levels of the military sections’ hierarchical structure. This is because one can determine that erecting a girder-bridge, for which the quantity survey unit is 100 meters, requires 30 hours of work of a bridge-construction battalion, that is 30 battalion hours; one system of obstacles and demolitions consumes 10 platoon hours (10 hours of work of one platoon), etc. Thus, in planning it will be necessary to monitor the labor engagement of each of the sections and examining the possibilities of assigning specific forces for executing the subsequent tasks. Computer analyses of this kind require using the presented models.

The original issue solved in this article is the model of analyzing hierarchical-structure resources ensuring controlling the availability and engagement of the resources in allocating units of a complex structure for given works. This model is applicable when designing the decision facilitation systems in planning military and engineer operations. In such operations are engaged hierarchical-structure units (battalions, companies, and platoons). “Qualifying” the units of such structures using the computer requires taking under consideration the fact of units “nesting” in others. Appointing for work, for example, a sappers’ company of a sappers’ battalion additionally results in demobilizing the sappers’ battalion (this battalion is already an unavailable resource) and separating all the subresources of the sappers’ company. Apart from the method of “qualifying” complex resources, in this work has been formulated a model of allocating a hierarchical structure for works on the separated work fronts. The model enables an automation of calculations aimed at designating the contractor for the set of tasks executed on work fronts, based on their labor consumption referred to the resources of any of the levels of a hierarchical structure.

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