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Formation of the model of planning and management of linearly - extended structures construction with the rated level of reliability

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Abstract: In this paper the methodical sequence of assessment of the planning level and construction management linearly - extended constructions are considered. There are defined main directions of improving the effectiveness of the plans of organizational and technological reliability of the construction of buildings by private phased assessment criteria and planning generalized quality criterion.

Key words: Construction, Linearly extended structures, Organizational and technological reliability, Criteria, Management, Planning, Quality, Efficiency, Profitability, Generalized assessment

1. Introduction

It is known that the construction of the linearly extended structures (LES), such as subway lines, is characterized by a certain constructive monotony in case of essential organizational and technological complexity of works. Therefore the extraordinary approach for reasonable forming of the line organization of works, quality control and the course of schedule performance of construction of buildings, ensuring high level of organizational and technological reliability of a construction of LES and effective planning and management of production processes are required [1, 2, 3].

At disclosure of the term "organizational and technological reliability" proceeded from the published works [4, 5], and also from classical definition of the concept "reliability" [6] including a complex of properties: non-failure operation, maintainability, durability, installation suitability, keeping. So, in relation to the management of processes of construction of LES "non-failure operation" it is possible to understand as time of implementation of plans without failures and deviations. This time can be considered from the beginning of work on again modified plans until the beginning of the following stage of adjustment because of emergence of inadmissible deviations and failures.

"Maintainability" (recoverability) can be measured by the time required for the collection of information, its processing, decision-making on the adjustment plans while increasing performance indicator and bring solutions to the performers. In total time of trouble-free functioning of the accepted plan and time of adjustment ("recovery") of plans can be considered as duration of a complete cycle of charge from collection of information before implementation of the taken managing decision.

"Longevity" in relation to the organizational and technological reliability schedule can be viewed as the time of its operation to complete restructuring plans or to their complete replacement by newly developed plans.

"Installation Suitability" can be considered as time spent, if necessary, to perform work on the installation of equipment and associated with the restructuring of this part of the schedule.

"Shelf life" can be considered as the time during which the developed schedule retains its relevance and effectiveness, and with its adjustment does not require additional resources, change priority and sequence of erection of structures and implementation milestones.

All LES construction process and the implementation of planning decisions can be regarded as consisting of stages of trouble-free operation without failures and violations, intensity adjustment stages , the sequence of construction of structures and stages of complete plans restructuring (on terms and sequence) of the building structures with additional resources in different periods of production process. Then, at each stage of liquidation of lagging or deviations from earlier accepted plan, it is necessary to choose such scheme of continuation of works which would minimize the general amount of increase in additional costs [7, 8, 9].

All of the components of reliability, which have a dimension of time, are random variables. These values are set by distributions of probabilities and are sufficient characteristics of components of reliability [10]. At the same time a number of researchers [4, 11, etc.] believe that for construction

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it is expedient to consider reliability from a position of completion of works at the scheduled time. I.e. reliability is understood as probability of achievement of necessary qualitative results for the required time. If there is a failure of construction time on the important stages or in the final stage, the value of the planned efficiency decreases. This raises the problem of combining the reliability of plans and their efficiency, reliability, implementation and management effectiveness [12].

2. Materials and methods

The analysis of construction production and process of control of its development shows that the main major parameters characterizing the state of the building, is the presence of objects of all kinds of resources required - R and degree of readiness of objects to put in the -G operation.

Provision under construction resources (labor, technical, material, energy, etc.) Is determined by the actual presence R_i^f (1 = 1, ..., n) and planned (required) R_i^P(1 = 1, ..., nn) volumes of resources. Where n – is quantity of actually present types of resources, and nn– quantity of the required types of resources. At the same time the condition of security with resources needs to be considered in dynamics of construction of objects for adequate reaction of governing bodies.

It is also expedient to consider degree of readiness of objects in dynamics of construction of objects for timely taking measures at lag of the actual degree of readiness of G_j^f-object from the planned G_j^P

The degree of readiness of an object is determined by summing of extent of accomplishment of separate constructs or work types, by extent of development of the allocated investments, and for linearly - extended constructions – by length of the executed route of a tunnel of the subway.

Considering the number of the arriving data on deviations and delays in time, it is possible to determine the duration of decision-making period – duration of one cycle of management T_{man}. On the other hand the duration of the management cycle for compensation the arisen failures (satisfaction of requirements of the operating decisions) can be defined by the management technology.

$T_{man} = t_{sv} + t_{inf} + t_{pr} + t_{isp} + t_{per}$,

where t_{sv}– the duration of the period of implementation of the plan without essential deviations (trouble-free work);

$t_{inf} + t_{pr} + t_{isp} + t_{per}$– stages of duration of the information collection; development of managing decisions; their transfers for execution; implementations of the current decisions, respectively – duration of maintenance of the functioning plan (maintainability or restorability).

The planned degree of an object readiness can be defined at any moment from expression:

$$G^p = g^p \times t,$$

where g^p– the planned availability growth rate per unit time of the object;

$0 \le t \le T_{dir}$; where T_{dir} – the determined time in a directive way.

The actual readiness of the object at any given time can be determined from the expression:

$$G^{fact} = G \cdot t^P - \sum_{f=1}^{F} K_{dec_f} \cdot g_f^P \cdot \left(t_{inf_f} + t_{resh_f} + t_{per_f}\right) + \sum_{f=1}^{F} K_{inc_f} \cdot g_f^{\Pi} \cdot t_{sv_f}$$

Where *F* - quantity of management cycles during the time *t*;

K_{dec_f} - the coefficient of the actual decrease in the planned growth rate of an object readiness; $K_{dec_f} < 1$

K_{inc_f} - the coefficient of the accepted increase in growth rate of an object readiness for one cycle of management *f* for neutralization of negative impact of failures and delays; $1 \le K_{inc_f}$.

Here

$$t = \sum_{f=1}^{F} \left(t_{inf_f} + t_{resh_f} + t_{per_f} + t_{sv_f}\right).$$

As $K_{inc_f} \cdot g_f^P$ can not significantly exceed the planned speed without attraction of additional resources or existence of considerable time, as a rule, the actual degree of readiness of an object is noticeably less than planned. Besides, it is necessary to consider that t_{sv} generally is less than the sum of $t_{inf} + t_{resh} + t_{per}$. and this further increases the backlog of readiness of the object from the sum planned values $t_{inf} + t_{resh} + t_{per}$ – ΔOTC.

$\Delta отс = G^P - G^F$.

To improve the reliability, compliance with the planned values of construction parameters when $\Delta omc \to 0$ it is necessary to try to obtain the existence of reserves of resources and time when developing planned decisions for increase in opportunities $K_{inc_f} \cdot g_f^P$ and reduce the value T_{man} to reduce the number of delays and opportunities $K_{dec_f} \cdot g_f^P$.

The impact of the external environment can be viewed as a stream of demands for the development of control actions (decisions) to compensate the arising deviations, missed deadlines and delays in the works execution. Such requirements stream (stream of disruptions and delays) can be attributed to a simple stream and described by the Poisson function [13]:

$$Pk(t) = (\lambda t)^k \cdot \frac{e^{-\lambda t}}{k!}$$

where Pk (t) – the probability of *k* requirements receipt on the operating decisions during the time 0 – t;

λ – the stream parameter – average of the requirements arriving per unit of time;

e – basis of a natural logarithm.

On the basis of expression (1) it is possible to determine the duration of a management cycle to reduce the volume of influence of the arising delays. When $\lambda t = T_{man} \le 1$ the probability $Pk(T_{man})$ reaches the values 0,4 – 0,6, that corresponds to the absence or the occurrence of a slight delay (on the control action requirements).

Then $T_{man} \leq 1/\lambda$. In this case emergence of delays and their impact sharply decreases, and management of the course of construction process becomes more effective.

The considered LES construction parameters significantly influence on the quality of management. For a quality evaluation and management efficiency it is necessary to determine the main criteria and indicators directly of management process, i.e. to execute researches of the importance and ponderability of criteria of quality of construction management of LES.

Quality of LES construction management is set of organizational and technological properties of the managing director and managed subsystems, characterizing dynamics of resource consumption for management (informational, labor and technical) and issues of managing decisions (teams) causing a capability of a production subsystem to creation of construction products with minimum possible (set) level of economic costs, with the required quality level and in planned terms.

Due to the fact that the building system consists of two subsystems, the management construction quality indicators should be viewed from two perspectives - from the perspective of the functioning of the control subsystem and the position of the managed subsystem.

From the standpoint of controlling subsystem main indicators of the quality of management are:

- degree of compliance of an organizational structure of management personnel to tasks and structure of a production subsystem PK_{dc};
- timeliness and efficiency of response to changes of production situations PK_{sr};
- adequacy and efficiency of the made decisions (teams) PK_{pr};
- profitability of functioning of a subsystem of management PK_{ec};
- reliability of management personnel work PK_{rm}.

From a production line item the main indicators of quality of management are:

- rhythm and uniformity of production (growth rate of readiness of an object) $-KP_{rp}$;
- degree of compliance of the actual indicators of production to planned Ksp
- level of quality of construction production KP_{kp}
- profitability of construction production KP_{pc}
- reliability performance of production targets KP_{rp}

The management quality of LES construction as a system on the basis of the analysis of the main indicators on subsystems can be characterized by the following generalized indicators in general:

- degree of compliance of the actual indicators of construction process to planned P_{dp}
- level of the construction production quality P_{qp};
- profitability of the construction system functioning P_{ec};
- reliability of the construction system P_{rs};

It is conditionally possible to assume the following expressions.

$PK_{dc} + PK_{sr} + PK_{pr} + KP_{kp} = P_{dp}$

$PK_{pr} + KP_{kp} = P_{qp}$

$PK_{ec} + KP_{pc} = P_{ec}$

$PK_{rm} + KP_{rp} = P_{rp}$

Forming criteria of quality of management of construction on the basis of quality indicators, it is possible to offer dependences:

$$K^1 = \sum_{i=1}^{m^1}\left(P_i^{1^P} - P_i^{1^F}\right) \Big/ \sum_{i=1}^{m^1} P_i^{1^P}$$

$$K^2 = \sum_{i=1}^{m^2}\left(P_i^{2^T} - P_i^{2^F}\right) \Big/ \sum_{i=1}^{m^2} P_i^{2^T};$$

$$K^3 = \sum_{i=1}^{m^3}\left(Z_i^{3^F} - Z_i^{3^P}\right) \Big/ \sum_{i=1}^{m^3} Z_i^{3^P}$$

$$K^a = \sum_{i=1}^{m^a}\left(H_i^{a^P} - H_i^{a^F}\right) \Big/ \sum_{i=1}^{m^a} H_i^{a^P}$$

where K^1, K^2, K^3, K^a - criteria of compliance of the actual indicators to planned: to the quality level of construction products, profitability and reliability of construction system respectively;

m^1, m^2, m^3, m^a– quantity of the accepted indicators of process of a construction, indicators (parameters) of quality of construction products, cost types on production and management, parameters of reliability of construction system respectively;

$P_i^{1^P}, P_i^{2^T}, Z_i^{3^P}, H_i^{a^P}$ - planned or required value of *i*-indicators of the construction process, quality of construction products, costs and reliability respectively;

$P_i^{1F}, P_i^{2^F}, Z_i^{3^F}, H_i^{a^F}$ - planned or required value of *i*-indicators of the construction process, quality of construction products, costs and reliability respectively;

Values of criteria of quality of management of LES construction in expressions (11)–(14) change ranging from 0 to 1 and have no dimension. Then it is possible to calculate value of the generalized criterion of quality of management.

$$K_{man}^{0} = \left(B^1 \cdot K^1 + B^2 \cdot K^2 + B^3 \cdot K^3 + B^a \cdot K^a\right) \Big/ B^1 + B^2 + B^3 + B^a.$$

The established indicators of management quality and the counted generalized criterion are allow to organize the process of management construction level optimization.

As the criterion function expression (15) takes a form $K_{man}^{0} \to \min$ the restrictions values of some indicators can be accepted. The personnel management establishes the significance value of quality criteria $B^1 + B^2 + B^3 + B^a$. Together with the considered indicators and quality criteria of LES construction management, for the creation and optimization of management personnel, the great importance plays the level of cost efficiency of construction system in general.

The economic efficiency of the system can be assessed by the direct calculation made by reducing the cost of implementation of the planned target for the entire system or the calculation of the relative indicator characterizing the ratio of management costs, and the resulting savings in production processes. The overall effectiveness of management can also be assessed for general management costs and the total amount of established construction products.

If the values of technical, technological, economic and organizational parameters are defined and set, provided the receipt of all necessary types of resources, the issue of construction products is carried out in the form of the stations and subway lines. Withstand the value of building production parameters form all the basic properties of construction products, such as quality, durability, serviceability, efficiency and others. Many of the properties are determined by the set values of the corresponding parameters. The most important properties should include speed of issuance of finished construction products, its quality and effectiveness.

Then, the *i*-feature of construction products has a corresponding functional dependence on the set of parameter values.

$W_i = F_i(TP, TXP, EP, OP)$,

where TP, TXP, EP, OP - vectors of the technical, technological, economic and organizational settings.

The volume of construction products which is produced during the Δt time period, defined by the following functional dependence:

$$V_{pr}^{\Delta t} = \sum_{i=1}^{N} V_{pr_i}^{\Delta t} = \sum_{i=1}^{N} F_{pr_i}\left(TP_i^{\Delta t}, TXP_i^{\Delta t}, EP_i^{\Delta t}, OP_i^{\Delta t}\right)$$

where $\Delta t = t^1 - t^2$ - period of rhythmic functioning of production from t^1 to t^2;

$\left(TP_i^{\Delta t}, TXP_i^{\Delta t}, EP_i^{\Delta t}, OP_i^{\Delta t}\right)$ - vector values of technical, technological, economic and institutional settings during the time Δt for *i*-type of work;

N – the number of work types on the facility;

Now the volume of construction products issued per time unit, per the period T, will be

$$G_{sr} = \sum_{f=\Delta t}^{T} V_f^{\Delta t} \Big/ \Delta t_f .$$

The quality score of finished construction products for the considered time period, also depends on set parameters:

$$KP_{sr} = \sum_{i=1}^{N} KP_i / N = \sum_{i=1}^{N} F_{KP_i}\left(TP_i, TXP_i, EP_i, OP_i\right) / N$$

where KP_i – indicator of i-type of work production quality;

F_{KPi} – functional dependence of quality indicators on i-type of work from parameters of construction production.

It is similarly possible to describe the dependence of economic efficiency

production on the parameters of building production:

$$E_{EP} = F_{EP}\left(TP, TXP, EP, OP\right) = \left[\sum_{i=1}^{N} V_i\left(Y_i - C_i \cdot \Psi_{OP_i} \cdot \Psi_{TXP_i} \cdot \Psi_{OP_i}\right) - E_{IN} \cdot J\right] \cdot \Psi_{EP}$$

where V_i – the volume of construction products of *i* –type of works (structures) for the considered time period;

Y_i – construction products unit price of *i* –type of works (structures);

C_i – total costs on creation of unit of construction products of *i* –type of works (structures);

$\Psi_{OP_i} \cdot \Psi_{TXP_i} \cdot \Psi_{OP_i}$ – coefficients that take into account the impact of the overall cost of construction to create products for the i-th type of works (structures) from the technical, technological and organizational parameters, respectively;

Ψ_{EP} – coefficient taking into account the impact of economic variables on the economic efficiency of building production;

E_{IN} – coefficient of economic efficiency of investment processes;

J – the volume of investment at construction of the considered object.

Parameters of building production determine many properties of construction products and the specific values of the parameters are established governing bodies through the processes of the organization, planning and management.

As it was noted above, a generic quality management criteria K_{man}^0 includes a particular criteria, matching actual performance planning, the construction of product quality, efficiency and reliability. Similarly, we can consider and generalized quality criterion of organizational and technological reliability (OTR) construction of LES.

As the special quality criteria OTR, based on analysis of construction options, we can take the criterion of a conformity of work adopted by the directive specified duration K_{pr}; criterion of free fronts of works usage K_{fr}; criterion of a continuity of production resources usage (labor, technical, etc.) K_{ur}; criterion of combination (threading) of works K_{CW} and criterion of probability of performance of work with the set indicators K_{pw}. The general principle of calculation of private criteria can be reflected by the expression:

$$K_i = P_i^{fact} / P_i^{opt}$$

Where P_i^{fact} and P_i^{opt} - are values of OTR indicator of the construction at the accepted option and at the greatest possible value.

Values of private criteria of OTR construction quality of LES fluctuate ranging from 0 to 1. Then the generalized criterion can be determined by the expression:

$$K_{otn}^{0} = (K_{pr} \times Z_{pr} + K_{fr} \times Z_{fr} + K_{ir} \times Z_{ir} + K_{pt} \times Z_{pt} + K_{vr} \times Z_{vr}) / (Z_{pr} + Z_{fr} + Z_{ir} + Z_{pt} + Z_{vr}),$$

where Z_{pr}, Z_{fr}, Z_{ir}, Z_{pt}, Z_{vr} - the established values of coefficients of the importance for private criteria of the organization of construction respectively.

The generalized criterion of quality of planning is also determined on the basis of private criteria. It is possible to refer to the private criteria: criterion of compliance to the planned duration of a construction of constructions (stages and complexes of works) to standard values $K_{pr.s}$

The criterion of compliance of the planned completion dates of structures construction (stages and complexes of works) to directive values $K_{sr.o}$; the criterion of effectiveness of the planned dynamics of investment $K_{ef.I}$; organizations of their opportunities $K_{m.o.}$; compliance with the planned use of funds established by the investment volume criterion $K_{ob.i.}$ and the reliability of the developed plans $K^0_{отг}$.

Private planning criteria of quality in the final calculation are determined in accordance with the expression (21), but the calculation of intermediate values is performed based on the number of structures and resources of the species.

$$K_{pr.s.} = \sum_{i=1}^{m} \left[t_i^{HP} \Big/ \left(t_i^{HP} + \left| t_i^{HP} - t_i^{ZP} \right| \right) \right] \Big/ m ,$$

where m– is a quantity of the considered structures (stages and complexes of works).

The criterion of compliance $K_{sr.o.}$ is calculated on similar (23) dependences, only instead of duration of construction of i-structure the completion dates of construction are accepted.

The efficiency of investment dynamics can be estimated through reduction of investments occurring at different times by the beginning of planning period

$$K_{ef.d.} = K \Big/ \left[\left(1+E_i\right)^T \cdot \sum_{t=1}^{T} K_t \Big/ \left(1+E_i\right)^t \right]$$

where K – the total investment in the construction of the LES complex;

E_i– the reduction coefficient of multi-investment to the same point in time;

T – the duration of the LES construction complex set in the established temporary stages;

t – temporary stages of providing investments;

K – the volume of investment represented in t-timepoint.

The criterion of compliance of the planned required capacities of contract organizations to their opportunities can be calculated according to (23) with the accounting of contract number organizations or types of the considered capacities:

$$K_{м.о.} = \sum_{v=1}^{V} \left[M_v^{MB} \Big/ \left(M_v^{MB} + \left| M_v^{MB} - M_v^{MP} \right| \right) \right] \Big/ V$$

where M_v^{MB}, M_v^{MP} – the allocated and planned capacities of contract organizations by v-type (complex) of works respectively;

V – quantity of the considered types of capacities.

It is possible to use the similar expression for the definition of $K_{ob.}$ Value:

$$K_{ob.i.} = \sum_{t=1}^{T} \left[K_t \Big/ \left(K_t + \left| K_t - K_t^{pl} \right| \right) \right] \Big/ T$$

where K_t^{pl} – the planned volume of investment into *t*-timepoint.

The private criterion of reliability is equal to $K^0_{OTR} = K^{0\ факт}_{OTR} / K^{0\ dir}_{OTR}$.

The generalized criterion of quality of planning by analogy with (23) can be calculated from the expression:

K^0_{pl} = ($K_{pr.s.}$ × $З_{pr.s.}$ + $K_{sr.o.}$× $Z_{sr.o.}$ + $K_{ef.d.}$ × $Z_{ef.d.}$ + $K_{м.о.}$ × $Z_{м.о.}$ + $K_{ob.i.}$ × $Z_{ob.i.}$ + $K_{n.p.}$ × $Z_{n.p.}$) /

/ ($Z_{pr.s}$+ $Z_{sr.o}$+ $Z_{ef.d.}$ + $Z_{м.о.}$ + $Z_{ob.i.}$ + $Z_{n.p.}$).

3. Results and discussion

The unity of methods of management and technology of management are shown that the accepted specific method for their implementation requires a certain technology. The choice of this or that method depends on specific type of a construction, on specific conditions of production, on the required duration of a construction and other reasons. To manage the process, it is necessary to perform certain procedures and in a certain sequence, as determines a method and technology of management.

In accordance with the production structure of any enterprise management theory, including the construction of the system, must comply with the tasks of production, production processes and technology, form and scale of production. The management structure is a series of specialized units, staffed by employees and management with certain forms of organization and communication. Each unit is aimed at the performance of specific tasks that make up a specific control function. The structure and content of management functions follow from the tasks facing the construction production. It is possible to carry to managerial functions: planning and forecasting, development and enhancement of technology and the equipment for specific types of underground works, completing and training, material logistics of a construction, financial accounting and control, etc. The amount of managerial work and content of management functions also determines structure of management personnel. Thus, the number of the main functions determines structure of management personnel, extent of compression of information on levels of management. The number of management staff substantially depends on the amount of construction production.

The impact of organizational and technological parameters on the economic parties of management process can be researched against the background of the efficiency of construction production and management.

It is possible to refer the allocation of certain types and complexes of works, forming of specific sites in construction space to processes of forming the elements of the organization, purpose of necessary types of labor and technical resources to the allocated sites on the established work types, a reasonable combination of elements of internal production structure, purpose of reasonable consumption of all types of resources and creation of rhythmical production of finished goods on the basis of the line organization of works. In total management of a construction organization can be considered as effective if it establishes:

- Suitable and effective combination in time and space of human and technical resources;
- Rational and economical use of all resources in the process of construction and management at any given time;

- Organizing the internal structure of production and the governing bodies at every stage of construction, aimed at the highest productivity;
- Determination of the most appropriate pace of construction and installation works and distribution of all kinds of resources, providing the tasks of building at a set level of quality, low cost and within the required time;
- Elimination or weakening of the influence of adverse factors in the construction production in reasonable amounts and at low cost.

Mutual impact of technology of accomplishment of complexes of works and management can also be considered on the following line items:

- forming of possible and reasonable technological options of works performance on various sites (fronts) of works and determination for them the key parameters and indicators;
- the determination of possible technological complexes of works providing reasonable use of labor and technical resources;
- forming of the most rational technological scheme of accomplishment of all considered complex of works on an object in case of achievement of the quality objective, minimum of costs and in required terms;
- the elimination and easing of adverse technology factors in case of the minimum deviations from the established indicators due to the acceptance of alternative technologies.

The regulation and construction management on the basis of organizational technology solutions includes change of technological schemes of works performance and structures construction, the labor and technical resources redistribution, changes of a priority of private fronts of works development, methods changes in works organization. These changes bear organizational and technological parameters values changes and, therefore, change of the sizes of finance costs. Development of the managing decision shall provide the minimization of a deviation from the size of planned finance costs and provide the efficiency of managing system. The main objective of the managing decision is preserving the main planned targets in case of the minimum increase in finance costs.

To ensure the high reliability implementation of the LES construction legislative tasks is needed not only the development of plans to build subway lines, stations and other structures with a high degree of reliability, but also their implementation at all stages during the construction with the same degree of reliability. The operation of the entire control system in this case should be subject to a single management strategy and is aimed at ensuring the required level of reliability. Formation of a unified strategy for the entire period of construction and realization of its in planning, monitoring, forecasting, management, etc. is impossible without a unified, common approach to the whole process of management in the form of a generalized model.

The management cycle content which is considered above, allows to allocate the following constituent elements of the generalized model. Planning, information collection, construction condition assessment, forecasting, determination of duration of a management cycle and development of the adjusting decision are the elements of this model. At the same time planning, forecasting and installation of duration of the management cycle are made several times, and assessment of a construction condition and development of the managing decision are made on each management cycle.

During the construction of the LES complex two systems interact - on one side is seen and realized the planned construction system, on the other hand is implementing a production system plan. The system of built structures from the control position can be described as a matrix V = { vij } , where i = 1,...,n and j = 1,..., m, vij - matrix elements.

The quantity of the constructions and complexes *n* which are subject for the construction is characterized by a certain quantity of *m* indicators. Similarly the production system can be described a matrix W = { wij }, where i = 1, …, T and j = 1, … p, wij - matrix elements. Here the duration of functioning of a production system *T* and each time span is characterized by a certain quantity of *p* indicators.

The resource indicators are the basic indicators of structures and systems of the production system:

- the required and allocated financial resources;
- the required and available material resources;
- technical resources, required and ready to use;
- the required and available manpower.

The temporary and priority parameters are determined for structures under construction, exactly, the duration of their construction, deadlines, start and finish work order, and so on. These parameters have a significant impact on the organization of the functioning of the production system.

The management task is the management vector R forming, which provides the creation of the planned complex of constructions with forces of a production system for the period to time $T_{dir.}$ taking into account the required and allocated sizes of the main indicators. At the same time the frequency of forming and the depth of impact of a managing vector shall provide the high reliability of LES construction in set terms in case of the minimum costs. In connection therewith the generalized model includes the following elements. In accordance with this the generic model includes the following elements.

1. The development of initial and intermediate planned decisions.

To create the management vector *R* for the interaction of LES system with a production system, which provides the optimum reliability value of developed planned structure implementation.

$$U^{\underline{0}} = Fpl\ (R) \rightarrow opt,$$

when

$Fc^{\underline{0}} = Ff\ (R) \le Fc^{w};$

$M^{\underline{0}} = Fm\ (R) \le M^{w};$

$A^{\underline{0}} = F\alpha\ (R) \le A^{w};$

$B^{o} = F\beta\ (R) \leq B^{w}$;

$T^{o}ок \leq T^{d}ок$; $T^{o}pr. \leq T^{d}pr.$; $Pr^{o} \leq Pr^{d}$;

$H^{o} = F^{h}(Fc^{o}, M^{o}, A^{o}, B^{o}, T^{o}ок, T^{o}pr.) \geq Hz$.

where: Fc^{o}, M^{o}, A^{o},B^{o} – are vectors of economical and financial structure, consumption of material resources, applied technical resources and used manpower accordingly;

Fc^{w},M^{w}, A^{w},B^{w} – are vectors of economical and financial opportunities, representation opportunities for construction material technical and manpower accordingly;

$T^{o}ок$, $T^{o}pr$, Pr^{o} – are vectors of deadlines for structures construction, buildings and construction duration priorities accordingly;

$T^{d}ок$, $T^{d}pr$, Pr^{d} – are vectors of maximum allowable deadlines for structures construction, buildings and construction duration priorities accordingly;

H^{o} – the reliability vector of LES construction planned structure realization.

2. The monitoring and control regime definition.

To determine the duration of the management cycle, which provides a possibility of achievement of the minimum deviation of the actual speed of construction from planned

$\Delta Gpl = Fman(R) \rightarrow min$,

when

$\Delta G = Ft(Tman)$;

$guv. \times Tman. > \Delta G$.

3. The condition formation of the system construction at the timepoint T_{rasch}.

$\Delta Gt = Ft(\Delta Fct, \Delta Mt, \Delta At, \Delta Bt, \Delta Tок.t, \Delta Tpr.t)$,

when

$\Delta Fct = Fct - Fspl.$;

$\Delta Mt = Mt - Mpl.$;

$\Delta At = At - Apl.$;

$\Delta Bt = Bt - Bpl.$;

$\Delta Tок.t = Tок.t - Tок.pl.$;

$\Delta Tpr.t = Tпр.t - Tpr.pl.$

4. Forecasting of the construction system development during T_{rasch}.

To calculate the forecast of an object readiness growth and to define the period of compliance to planned values

$Gt = \Omega^{1} + \Omega^{2}xt \rightarrow Gtpl.$,

when

$\Omega^{1} = 2S(T) - S(T)^{[2]}$;

$\Omega^{2} = \alpha/\beta x\ [S(T) - S(T)^{[2]}]$.

5. The development of current management decisions.

To generate control and management vector *Rman.*, which provides a minimum deviation from the accepted level of reliability on the ongoing plan.

$\Delta U^{t} = Fman\ (R^{t}man) \rightarrow min$,

when

$Fc^{t} = F_{f}\ (R^{t}man) \leq Fc^{w}$;

$M^{t} = F_{m}\ (R^{t}man) \leq M^{w}$;

$A^{t} = F_{\alpha}\ (R^{t}man) \leq A^{w}$; (51)

$B^{t} = B_{\beta}\ (R^{t}man) \leq B^{w}$; (52)

$\Delta H^{t} = F_{h}(Fc^{t}, M^{t}, A^{t}, B^{t}, T^{t}ок., T^{t}pr.) - H^{o}$. (53)

The considered generalized economic and mathematical planning and management model allows to carry out the construction projects strictly according to the approved program.

4. Theoretical and practical implications

Construction is a large complex system, whose main task is the creation of construction products with the desired properties. The system operates within certain parameters and generates construction products with specific characteristics. The indicators of construction products include its cost, durability, reliability, functional fitness and others. The parameters of functioning of the building systems define indicators of finished construction products and have a significant impact on the efficiency of building production.

The parameters of construction, characterizing the process of building construction products in the form of tunnels and determines its quality indicators, you can include technical, technological, economic and organizational settings. Each of these groups characterizes by the one aspect of production process and ultimately determines the total amount of social labor costs. The structure of the most important technical parameters of LES construction should include numerical and qualification of the production staff, installed power production and the level of automation of production processes. Improving the reliability of the plans at the same time improves the efficiency of the construction process (Fig. 1 and Fig. 2).

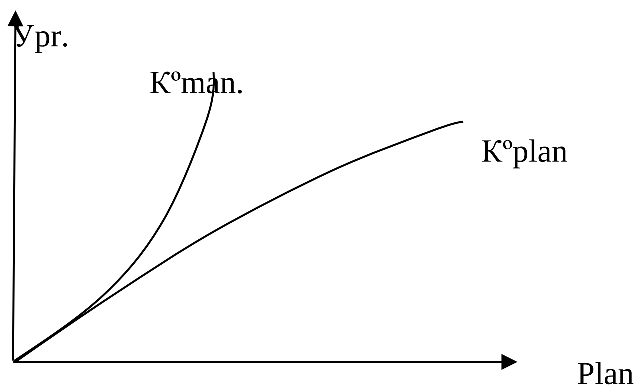

Fig. 1: The interrelation between indicators of planning and management

In a general view it is possible to allocate the following methods of increase the LES construction operational and technological reliability:

- the creation of construction plans of objects with the greatest possible level of reliability for the account: applications of the acquired technological processes; uses of the available park of the serviceable cars and technical devices which are guaranteed in due time arriving on the building site; selection of the trained and technically competent manpower;

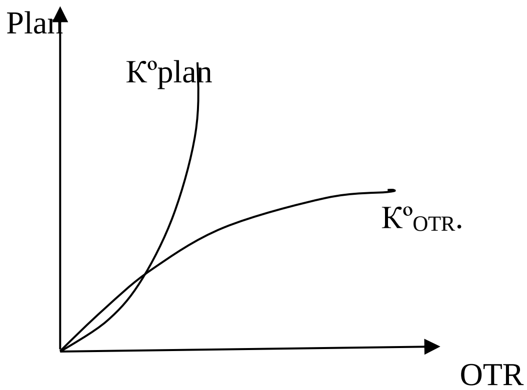

Fig. 2: The interrelation between indicators of reliability and planning

- the introduction of structural and temporal redundancy plans at the expense of prescribed equivalent technologies, alternative sequences and sequence circuits of work, by assigning the most probable duration of work, with time to spare on their deployment and implementation;
- the organization of sufficiently intense cycles of monitoring the construction progress and its compliance with the parameters adopted by the parameters of the plan. The control cycle proceeds in the control at dangerous deviations from planned targets;
- the organization of improved external conditions for qualitative execution of the plans (effective organization of the construction site, improving the conditions of work in the tunnels, timely delivery of materials and structures, and others.).

It is known that the subject methods, which forming a certain level of reliability, can be divided into two areas (aspect reliability) - operational and functional [6, 7]. The operational aspect involves methods for selecting the plan structure, formation and calculation of the main parameters of the plans; correction and conversion targets. The functional aspect regards methods of implementation of strategies and plans, indicators, data collection, transmission and processing of information, analysis and forecasting of the state of malfunction and the feasibility of the leading targets.

From here, the high level of reliability of the created plans in combination with the established LES construction efficiency is achieved by using the full operational aspects of the reliability methods. The implementation of high rates of the plan under construction is reached by the effectiveness of management and requires the accurate organization of work of management bodies and the high-quality organization of processes of management activity that represents a functional aspect of reliability.

The accumulated experience of LES construction allows to allocate the following main directions of the management enhancement:

- the enhancement of organizational structures and forms of government construction production;
- the enhancement of construction management methods of objects;
- the ensuring necessary level of reliability of construction processes and cost efficiency of production and management;
- the application of computer facilities on handling of management information and development of technology of management in a construction;
- the application of mathematical methods and economic-mathematical models for development and optimization of management decisions.

The enhancement of organizational structures and forms of government production provides the cost reduction on management personnel and increasing its work effectiveness. Process of production management is implemented through the accomplishment of separate types of managerial work.

5. Conclusion

In general the considered construction process parameters rather fully determine indicators of quality and efficiency of its production and management. It is possible to carry to these indicators: timeliness and efficiency of reaction of management personnel, efficiency of the made decisions, reliability of production and management, rhythm and uniformity of production, products quality level, profitability, etc. The offered indicators of production and management allowed to create a number of criteria for assessment and the choice of the most effective methods of ensuring organizational and technological reliability and construction of facilities. The offered specific private dependences allowed to receive the settlement dependence of the generalized criterion of quality of planning and LES construction management.

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