Journal of Scientific Research and Development 4 (1): 16-25, 2017
Available online at www.jsrad.org
ISSN 1115-7569

Development of a model of planning and management of construction of linearly extended structures with high level of organizational and technological reliability

Gasim Abdullayev Israfil oglu *

Doctor of Technical Sciences, Leading specialist of the Scientific and Methodological Center "Odlar Yurdu" University, AZ1072, Koroglu Rahimov street, 13, Azerbaijan Republic, Baku

Abstract: The generalized structure of software systems form the organizational and technological models of building linearly extended structures was considered. The method of determining need for human, material and financial resources was developed. The scheme of interaction of elements of calendar planning system was given. A sequence of evaluating of terms of performance of individual works with beta distribution law was developed, as well as the calculation of the objective functions and the formation of the limitations with the assessment of their validity.

Key words: Construction management, Linearly extended structures, Organizational-technological reliability, Planning, Construction works

1. Introduction

Modern complexes of engineering structures, characterized by a large extent, are distinguished by a significant variety of design and during their construction completely different complexes of construction machines are. Thus, during construction of automobile roads and underground tunnels different materials and constructions, and various machinery and equipment are required. Also considered linearly extended structures (LES) have a range of common properties These structures are particularly suitable for the organization of work, for building a production schedule with rhythmic work performance. Such structures have good capability to highly efficient and economic use of equipment and production machines, for the organization of high-performance process.

Improving the management of building linearly extended structures based on the use of new information and management technologies provides a significant economic effect and becomes in terms of business and contract market a major problem requiring urgent solutions. It is connected also to the fact that the development of commercial relations in the construction process of integration of developing construction companies, formed a system of logistics construction, enhanced communication cooperation, increased financial responsibility for the breach of contractual obligations. In a competitive environment, necessity of the survival of construction companies with the appearance of economic crisis and liquidity problems arise in the construction, improvement of organization and efficiency of the processes of erection of linearly extended structures as it contributes to the stabilization of the whole construction industry and its individual areas.

It is known that one of the most important factors in ensuring the planned level of effectiveness both functioning system of governance, and the entire production process of the linearly extended structure (LES) is the organizational and technological reliability (OTR) of production processes. This approach was described in other papers [1, 2, etc.] However, with regard to the construction of tunnels and underground lines, in the midst of a wide use of straight line work organization, the solution to the problem of ensuring high OTR level requires additional research.

In order to assess the reliability of the generated calendar plan positions perform the full scope of all the works within the prescribed time, in accordance with the provisions discussed above and probability calculation of indicators, a number of computational steps should be realised. First and foremost, there is necessity to calculate deadlines of all works of flow on the adopted method of organization. The calculation should be made on possible early and very late timing of execution of works. The duration of the works is established in accordance with the selected resources of all kinds, with two or three assessment methods.

Reserves of time for works for the flow the critical path is calculated under the usual method. Rhythmic flow has no reserves in individual works and calculation of reserves is not required. Non-rhythmic flows and flows with different rhythms do not require additional calculations for reserves amount determination. Time reserves have those

* Corresponding Author.

private flows, which are concluded between the other private flows, having a longer duration. The calculation can be performed on a matrix of performance time or graphics model based on the time scale. In calculating reserves of time in this case, a departure from the principles of formation methods of the organization of work is not considered.

Determination of reserves of time in private flows of resources and scope of work is carried out on the basis of predetermined terms for release of technical and human resources and on the given terms of readiness of bay and parts of the structure. Similarly, the reserves are calculated on the priorities on the basis of directively given values and values of the formed plan. For the line work organization the priorities have considerable value for parallel-line organization or under free priorities for implementation of certain types of work. Calculation of reserves of time is the first step in determining the calculated level of reliability.

The second step is to calculate the reserves of labor, technical, material and financial resources. With the calculated appointment of labor and technical resources, reserve is determined on the base of the allocation of additional unused resources. When there is excessive resource assignment, reserve can be determined on the basis of calculated values. However, an excessive assignment of labor and technical resources leads to a reduction of performance time and calculated additional time reserve automatically takes into account the resources reserve.

Reserve of material resources promotes timely and preterm implementation of works and may be taken into account in most cases in the volume of additionally allocated materials, parts and constructions. Additionally allocated funding may be considered similarly. Они обычно учитываются в расчете на весь комплекс работ, объединенных в поток, и на отдельные работы и частные потоки существенного влияния не оказывают. At the same time copiously allocated financial resources can significantly reduce construction time and provide high reliability of implementation of planned targets.

High-quality production results require a high level of information security, which is the collection and processing of information for substantiated planning and management decisions. Information provision should also be performed on an effective technology that forms the methodological principle of information technology. Information technology is a complex of interconnected scientific, technological and engineering provisions to ensure effective organization of labor for processing and storing information.

Formation of adequate planning and management solutions on the basis of information support can only be based on the probabilistic nature of the building production. The unreliability of many design, organizational and technological and constructional structures, dependence of current production developments on the external and internal conditions requires following probabilistic statistical principle. The principle is the probabilistic approach to the assessment of the main parameters of construction, registration of statistic data and denying of determinism of accomplishment events.

Improving the system of construction management of LES is one of the key issues of increasing the efficiency of the overall building production in the creation of tunnels and underground lines. The efficiency of management and production are interrelated indicators of the entire construction process. Determining the efficiency of construction management is methodologically reduced to the calculation of the ratio of costs for management and received at the same time improvement of the efficiency of production. Improving the efficiency of the production takes place at lower cost for the same amount of production or by increasing production volume without appreciable increase in costs or by increasing the quality of products at no additional cost.

2. Materials and methods

At the present stage one of the most important ways of increasing the efficiency of building production while creating LES is the application of the newest methods of designing organizational and technological solutions with a high level of reliability of their implementation [3,4]. At the same time, achievement of the desired level of efficiency of production requires the creation and operation of information systems for planning and management of the construction of the LES, considering the proposed models and methods of constructing solutions [5].

As part of an integrated information management system construction of the LES should be divided into three basic levels: level of calendar planing, financial-economic management level and the level of information support of the participants of the construction of LES [6].

General construction management technology of LES on the basis of the solution of tasks of calendar planing requires combining the work of investors, developers and contractors in one system. The functioning of this system and the interaction of its constituent elements is presented in Figure 1. 1.

Information technology should be based on block-integrated principle of building of of the entire volume of information that is used, its fragmentation into separate blocks (databases) in accordance with the functional purpose.

Formation of databank is aimed at addressing the major challenges of planning and managing construction of the LES. Therefore, information structures, forms and contents are subject to the formulation of decisions on the organization and technology of construction planning and management, as well as to monitor progress in the implementation of the project. The used methodology of the information system functioning should exclude the occurrence of high levels of risk and provide a sufficient level of reliability of the implementation of plans for the construction of LES [7-10].

In this regard, information technology planning and management includes the tasks that form the corresponding subsystem. Subsystems are combined by a common database and common users.

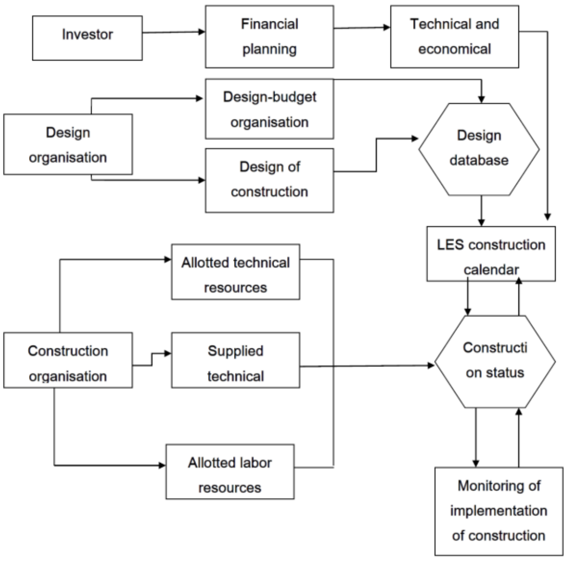

Fig. 1: The scheme of interaction of elements of calendar planning system

To solve a specific group of tasks it is practically to form an appropriate program complex with an access to the necessary database. One of the most important program complex in the construction of LES is the complex of calendar planing tasks. The generalized structure of program complex for calendar planing tasks can be represented as in the following table (Table 1).

The proposed program complexes and calendar planning system of interaction of structural elements provide a phased solution of organizational and technological problems in a systematic manner. In the first stage, the processing and approval of the estimates and project development are carried out. The estimated figures are related and are grouped according to specific work complexes and structures, as well as related to the established performers and contractors.

In the second stage leading construction companies carried out the formation of organizational and technological models of construction of LES through the allocation of appropriate scope of work, definition of manufacturing processes at existing structures and linking them in time and space into a single production complex.

At subsequent stages concordance is carried out on organizational and technological models with opportunities for investor to provide of financial resources, the possibilities for building organizations to allocate technical and labor resources, as well as the supply of materials, structures and equipment in the automated mode.

At the final stage, the optimization of the organizational and technological model is carried out to minimize risk and increase the reliability of its implementation. If necessary, the duration of execution of works can be changed to comply with restrictions on the volume of all types of resources allocated.

Terms appointed by the calendar plan, sequence and volume of work stages determine the necessary human and technical resources in order to maximize the efficiency of construction. That will ensure the minimization of all types of construction costs.

At the same time in the course of construction of objects under the influence of external and internal factors, failures and deviations from the calendar plan are possible due to violations of the planned organization and building technology, which substantially may increase costs and terms of work.

Since the main indicator design solutions of OTR is the probability of compliance with scheduled performance terms, the calculation of the probability of implementation of planned targets is one of the main stages of evaluation of reliability. From the offered different ways of calculating the probability indicators [11], to assess the of terms of performance the individual works or complex works, according to many researchers is the most appropriate use of PERT system [12], which is based on a law beta distribution under two valuation methods.

3. Results and discussion

Taking into account the methodology described above, expectations are equal to:

$M_x = (3a + 2b)/5$;

$m_x = (2a + b)$

variance- $D_x = 0.04\,(b - a)^2$.

Here *a* and *b* are optimistic and pessimistic evaluation of duration of work (work complex).

In assessing the probability of the deadline n private work flows, following one another in the same chain, the mathematical expectation, thickest value, and the variance of the final event can be defined as the sum of the mathematical expectations and the amount thickest values of events on the works included in this chain.

$$M_{\text{кон}} = \sum_{i=1}^{n} M_x i\,; \qquad m_{\text{кон}} = \sum_{i=1}^{n} m_x i\,; \qquad D_{\text{кон}} = \sum_{i=1}^{n} D_x i\,.$$

where *n* is the number of work flows in the chain.

Values of optimistic and pessimistic estimates of completion dates of private streams of works of all chain can be calculated by formulas:

$a = M_{kon} - (4\,D_{kon})^{1/2}$; $b = M_{kon} + D_{kon})^{1/2}$.

On the basis of the expression (3) the probability of implementation all private work flows on the chain can be estimated

$$p(T_z) = a_e^2 \cdot \left(3a_e^2 - 8a_e + 6\right)$$

Table 1: The generalized structure of program complex

No	Program complexes	Ongoing tasks
1	Entering and placement of the design-budget information	Entering information about the structures of buildings and budget information. Formation of specific structural elements of buildings. Grouping of information on organizational and technological solutions.
2	Formation of organizational and technological models of constructions of LES	Development of the partitioning scheme of buildings and work complexes on spatial bays. Complex formation processes. Determination of organizational and technological sequence of implementation of works. Construction of organizational and technological models for LES construction. Determination of the timing and sequence of works implemenation.
3	Calculation of the need for labor resources	Determination of the required number of performers. Calculation of the need for labor resources considering optimization of construction time.
4	The calculation of the need for material resources	Determination of the quantities of materials and structures. Calculation of volumes of material resources considering optimization of construction time.
5	The calculation of the need for technical resources	Determination on necessary technical resources. Calculation of the need for technical resources considering optimization of construction time.
6	The calculation of the need for financial resources	Determination of necessary financial resources. - Calculation of the need for financial resources considering optimization of construction time.
7	Optimization of organizational and technological models for construction of LES considering indicators of reliability	Calculation indicator of reliability for organizational and technological model. Determination of the timing and priorities for implementation of work complexes in order to maximize the reliability indicator values. Change the duration of the implementation of the work complexes to comply with the restrictions on resources.

where $a_e = (T_z - a)/(b - a)$ when $a < T_z < b$.

Line work organization is characterized by several private flows, timely completion of which influences timely completion of all work. Therefore, assessment of the probability of completion of the work flow is a relevant and sufficiently challenging.

As the development of the methodology outlined above, in the case of the presence in the complex more than two private flows fairly simple way is proposed [13] to calculate the probability of completion of the work within the given terms. With this purpose, first the calculation of the mathematical expectation the completion of the first two chains of work is made.

$M^{1\_2} = M^2 + \Delta M^{1\_2}$

where ΔM^{1_2} is determined in accordance with the degree of overlapping intervals of the beta distribution - strong or weak. [14]

The variance is determined by an expression

D1_2= (b2–M1_2)2/9

Borders of dissipation of the deadline for the two chains of work are determined by the expressions (5), and the probability for a given period of time - according to (6).

The values obtained for mathematical expectation and variance, as well as the calculated borders of dissipation once for the two chains of work, allow to consider them as one chain of works. Considering this chain of works together with the new one, the same steps of calculations can be repeated and the necessary parameters of the beta distribution determined. Similar calculations for all the considered chains of works enables to determine the probability of completion of all work on time.

Performing above calculations in full expediently carried out as a part of design studies in the formation of calendar plan on the large amount of work for prolonged period of its implementation. The results accurately reflect estimated probability and are scientifically substantiated. However, implementation of the plan in the process of adjustment, it is quite an approximate determination of the level probability of planned term of implementation of all the works to optimize and evaluate the plan at each stage of adjustment.

Since the process of construction of LES complex, two systems interact - on the one hand is considered and implemented the construction of planned constructions system, and on the other hand being implemented plan on the operation of the production system, then system of constructed buildings from the control position can be described by the matrix V = {vij}, where i = 1, ..., n and j = 1, ..., m (where vij- matrix element). Number of facilities (complexes) to be built n is characterized by a certain number of indicators m.

Similarly, the production system can be described by a matrix, W = {wij}, where i = 1, ..., T and j = 1, ..., p; Wij is the element of the matrix. Here, the duration of operation of T-production system and each temporal segment are characterized by a certain number of indicators p.

On this basis, for line work organization, when a number of private flows are executed in parallel with a certain degree of alignment, it is possible to offer a simple and effective expression. This expression has an empirical basis and takes into account the continuous increase in probable deadline for the works by increasing the number of parallel tasks.

$T_{pr} = T_{rasch}(1 + \Delta t_v)$

Where T_{pr} is expected duration of implementation of all the work;

T_{rasch} is the estimated duration of a complex of works, defined in a deterministic way of two or three assessments of the duration of implementation of each individual work by PERT system;

Δt_v is approximate estimate of prolonging work implementation with combining private flows,

$\Delta t_v = \beta\,(n - 1)\,(m + l)/\,2m$

B is coefficient taking into account the degree of rhythmicity private flows (0,004 - 0,025);

n is the number of private flows (chains);

m is the number of private work fronts (areas or structures).

Usually in the construction of LES volume of implemented work is quite significant. Thus a large number of building processes are performed either in parallel or with various degrees of alignment. In this case, the probability of the implementation of full range of work in terms is slightly reduced. Similarly, the expected completion time, which is calculated by the mathematical expectation, increases. The degree of increase in the total duration of work can be defined as for a flow by the following empirical formula

$$\Psi = \beta \cdot (n-1) \cdot (m+1) / 200 \cdot n$$

Then calculated the most probable deadline for the a complex of works (based on the corrected mathematical expectation) can be calculated from the expression

$T^p = T^p \cdot (1 + \psi)$.

The probability of implementation of a complex of works in the the set terms can be determined by well-known expressions for the beta distribution

$$P(T) = \alpha_д^2 \cdot (3\alpha_д^2 - 83\alpha_д^2 + 6)$$

Where $\alpha_d = (T - \alpha) \cdot (\sigma - \alpha)$;

α is parameter of the beta distribution; the shortest possible period of works implementation:

σ is parameter of the beta distribution; the shortest possible period of works implementation:

To assess the level of reliability in addition to the indicators mentioned above of other organizational and technological characteristics are also important. Arising fluctuations and deviations from the values of various parameters defined or planned their values, development tendencies of these abnormalities provide the greatest opportunity to assess the reliability of the implementation of the approved tasks.

To assess the reliability of the plan it is possible use the following indicators of deviations from the desired values:

- amounts of redistribution of resources between the considered forms of complex work and constructions - ΔP_i;
- amounts of additional resources $-\Delta P_{dop.i}$;
- timing resizing end range of works and construction works $-\Delta T_{ок.i}$;
- values change the duration of execution of works and construction works $-\Delta T_{pr.i}$;
- volume changes in priorities for coherence and prioritization of complex works and construction works $-\Delta Pr_i$.

Determination of the level of indicators deviation for assessing the reliability of the plan on the basis of organizational and technological parameters can be carried out according to the formula

$$H_{s.p.} = \sqrt{\frac{\Delta P^{2t} \cdot Y_r + \Delta P_{dor}^{2t} \cdot Y_{rd} + \Delta T_{ок}^{2t} \cdot Y_{to} + \Delta T_{pr}^{2t} \cdot Y_{tp} + \Delta Pr^{2t} \cdot Y_{pr}}{Y_r + Y_{rd} + Y_{to} + Y_{tp} + Y_{Pr}}}$$

where ΔP^t, ΔP_{dor}^t, $\Delta T_{ок}^t$, ΔT_{pr}^t, ΔP_r^t –the amount of changes of the corresponding organizational and technological indicators at *t* timepoint of assessment of level of reliability;

Y_r, Y_{rd}, Y_{to}, Y_{tp}, Y_{pr} – the weight and substance coefficients of organizational and technological indicators, respectively.

Here:

$$\Delta P^t = \sum_{i=1}^{n} \Delta P_i^t / n; \qquad \Delta P_{dop}^t = \sum_{i=1}^{n} \Delta P_{dop.i}^t / n;$$

$$\Delta T_{ок}^t = \sum_{i=1}^{n} \Delta T_{ок.i}^t / n; \qquad \Delta T_{pr}^t = \sum_{i=1}^{n} \Delta T_{pr.i}^t / n;$$

$$\Delta Pr^t = \sum_{i=1}^{n} \Delta Pr_i^t / n;$$

n-number of work complexes and structures.

On the basis of the expression (14) the objective function of the generalized model of production planning decisions LES construction can be described by the following expression

$U^0 = p \cdot (1 - \varepsilon/(1 + U_x^2)) \rightarrow \max$,

where p – coefficient of probability for objective function (0.7 -1.0);

ε – coefficient characterizing the rate of increase of the reliability of the planned structure, depending on the degree of deviation from the targets given directively (0.4 - 0.8);

$$U_x = (\sum_{t=1}^{T}\sum_{i=1}^{n} [x_{ti} \cdot (T_{pr.i}^D - (t_{ок.i}^P - t_{st.i}^P)) / T_{pr.i}^D + x_{ti} \cdot (t_{ок.i}^D - t_{ок.i}^P) / T_{pr.i}^D +$$

$$+ y_{ti} \cdot (Pr_i^D - Pr_i^P) / Pr_i^D + x_{ti} \cdot (Fc_i^D - Fc_i^P) / Fc_i^D + y_{ti} \cdot (A_i^D - A_i^P) / A_i^D +$$

$$+ y_{ti} \cdot (B_i^D - B_i^P) / B_i^D + y_{ti} \cdot (M_i^D - M_i^P) / M_i^D]) / n$$

the average value of the degree of the targets deviations of the directively given;

$$x_{ti} = \begin{vmatrix} 0 & \text{when} & t_i \neq t_{ок.i} \\ 1 & \text{when} & t_i = t_{ок.i} \end{vmatrix} \quad \text{when} \quad i = 1,\dots,n,\ t = 1,\dots,T;$$

$$y_{ti} = \begin{vmatrix} 0 & \text{when} & t_i \neq t_{st.i} \\ 1 & \text{when} & t_i = t_{st.i} \end{vmatrix} \quad \text{when} \quad i = 1,\dots,n,\ t = 1,\dots,T;$$

Expression (15) represents the reliability of the implementation of the planned structure in its realization, as well as the probability of the plan realization under normal conditions based on the probability coefficient p. Simultaneously, the final level of reliability is significantly influenced with the degree of deviation from the directively given targets -U_x. The lower planned targets than directively given one, the plan strength reserve and the higher the reliability of the accepted plan.

As restrictions accept the following expression:

$$T \le T_D; \quad T^P_{pr.i} = t^P_{ок.i} - t^P_{st.i} \le T_D, \quad t^P_{ок.i} \le T_D, \quad i = 1,\dots,n;$$

$$\sum_{i=1}^{n} Фc^{п}_{it} \le Фc^{д}_{t}; \quad \sum_{i=1}^{n} A^P_{it} \le A^D_t; \quad \sum_{i=1}^{n} B^P_{it} \le B^D_t; \quad \sum_{i=1}^{n} M^P_{it} \le M^D_t, \quad t = 1,\dots,T$$

Here:

$Fc^P_{it}, A^P_{it}, B^P_{it}, M^P_{it}$ is the volume of investment, technical, labor and material resources, the need for compliance with the plan in each i-construction (complex of works) every t-time;

$Fc^D_t, A^D_t, B^D_t, M^D_t$ is the volume of investment, technical, labor and material resources, and established by the governing and investing body in every t-moment of the LES construction.

The target function of the generalized model of management decisions production by analogy with (15) can be expressed as

Ut = ρ · (l – ε/ (1+ Ux2)) →max,

where

$$U^t_x = (\sum_{t=1}^{T}\sum_{i=1}^{n} [x_{ti} \cdot \left(T^P_{pr.i} - \left(t^f_{ок.i} - t^f_{st.i}\right)\right) / T^P_{pr.i} + x_{ti} \cdot \left(t^P_{ок.i} - t^f_{ок.i}\right) / T^P_{pr.i} +$$

$$+ y_{ti} \cdot \left(Pr^p_i - Pr^f_i\right) / Pr^p_i + x_{ti} \cdot \left(Fc^p_i - Fc^f_i\right) / Fc^p_i + y_{ti} \cdot \left(A^p_i - A^f_i\right) / A^п_i +$$

$$+ y_{ti} \cdot \left(B^p_i - B^f_i\right) / B^p_i + y_{ti} \cdot \left(M^p_i - M^f_i\right) / M^f_i]) / n$$

Here:

x_{ti} and y_{ti} – determined by formulas:

$Fc^p_i, A^p_i, B^p_i, M^p_i$ – the volume of investment, technical, labor and material resources set up by the taken plan at each i-construction (complex of works);

$Fc^f_i, A^f_i, B^f_i, M^f_i$ is levels of investment; technical, labor and material resources that actually exist during implementation of plan or that are expected during full implementation of the plan.

The objective function (21) is aimed at achieving the maximum level of reliability in the development of management decisions. At the same time it provides the lowest possible level of reliability deviation from the previously installed LES construction plan.

As restrictions accept the following conditions:

$$T^f \le T_d; \quad T^f_{pr.i} = t^f_{ок.i} - t^f_{st.i} \le T_d, \quad t^f_{ок.i} \le T^f, \quad i = 1,\dots,n;$$

$$\sum_{i=1}^{n} Fc^f_{it} \le Fc^p_t; \quad \sum_{i=1}^{n} A^f_{it} \le A^p_t; \quad \sum_{i=1}^{n} M^f_{it} \le M^p_t, \quad t = 1,\dots,T.$$

Here:

$F[0,1]c^f_{it}, A^f_{it}, B^f_{it}, M^f_{it}$ is the volume of investment, technical, labor and material resources actually used or planned for consumption according to the accepted management decision for each i-construction every t-time point;

$Fc^p_i, A^p_i, B^p_i, M^p_i$ is the volume of investment, technical, labor and material resources set up for consumption applicable in every t-time.

$\Delta H^t = U^t - U^{0} < \Delta H_{д}$,

where $\Delta H_{д}$ – allowable deviation of reliability when performing the plan from a given starting level.

Considered generalized planning and management model allows to make the current decision on the administration of the LES construction. Formation of decisions may be carried out only on certain techniques and algorithms, providing the best of plans and schemes of the organizations [15].

Formation of plan decisions that on the basis of model (15) - (20) requires significant in terms of Formation planned solutions based on a model (15) - (20) requires significant computational steps. The plan decision made on the basis of this model, provides the maximum possible value of the reliability of its implementation in compliance with the allocated resources and deadlines of separate facilities construction.

Great importance has the estimation levels weight of parameters and indicators of the OTR assurance system. This is related to the fact that the level of performance of the OTR assurance system and construction terms also depends on implementing features exactly on schedule to perform all of the complex of works: for the manufacture of materials, products and structures, to comply with the terms and technologies in the construction of buildings, as well as the efficiency of the building management system. The mentioned above can be formalized with the complex indicator of reliability:

R_{ct} =F_r (αMc, βCp, γTXp, ζУc),

when F_r – functional dependence of the reliability from compliance with the terms and technologies, as well as the efficiency of the building management system (monitoring, supervision and control), which is determined largely by the expert method;

αИк, βCp, γTXp, ζУc – assess the level of timely and accurate works implementation for the manufacture of materials and structures, meet deadlines and construction technologies, effectiveness of the control system operation. When determining the level of assessment weighting coefficients are taken into account α = 0.27, β = 0.40; 0.15; 0.18, which are defined by ranking factors of reliability. The coefficients a, β, γ, ζ can be specified with the accumulation of statistical data in the construction of certain subway lines.

Reliability index of construction processes is determined by estimates of These levels are defined as ratio of the number of stable strictly observed processes to their total number. These indicators are defined for each monitored parameter and are forming a single system of indicators, taking into account the generated weight coefficients.

Determination of weighting of various parameters and indicators is carried out by following ways:

- ranking process violations and delays;
- building matrix of the priorities;
- analysis of functions sensitivity to the emerging risks;
- rationing of volumes of violations and delays in physical or value terms.

Relative indicators can be used to assess the level of reliability and compliance with all construction terms taking into account already completed constructions in concrete terms: the probability of effective work performance terms compliance I_w, reliability characteristics I_r or the probability of violation of terms of I_t. These indicators can be calculated as the respective ratio of the actual values of the Iw, Ir, It to their configured values. Indicators of reliability are mathematically interconnected. For example,

Rct= Rf/Rd= F (Iw, Ir, It)/Rd

where Rf and Rd – factual and designed reliability levels;

F – standard normal distribution function.

Characteristics of reliability of timely and quality implementation of production processes, taking into account permitted defects in the construction of structures, can be estimated by the expression

$$F_n = \left(K_p \cdot K_d - 1\right) \Big/ \sqrt{V_r + \left(K_p \cdot K_d\right)^2 \cdot V}$$

where Cs and Cr – safety coefficient of structures and coefficient of reliability of the process. Average Cs value is from 1.2 to 1.6. C_r value for underground lines is from 0.92 to 0.97

V_r и V_r – variations in load construction and process reliability.

The actual probability of failure of the main buildings and structures according to the authors of a number of works exceeds the calculated values in the 8-17 times, for underground construction facilities in 3-7 times. In this regard, improvement of safety of structures lies in the increase of reliability and timely quality of processes. Improving the reliability of performance of technological schedules and plans increases the reliability of all the structural elements of buildings and automatically reduces the risks of the main types of accidents.

By substituting F_n in the expression, the extreme values of the considered parameters quantitative values were received for a more complete assessment of construction plans (schedules) reliability. For example, for monolithic housing construction was received P_H = 0.846, and for the underground station in Baku P_r = 0.885, but with the necessary amount of free resources. When developing basic design of reliability of timing and quality of construction processes, while improving technological regulations (routings) the indicators of performance of reliability of construction schedules can be significantly increased to values of 0.91-0.95.

This approach allows systematically assess the factors affecting the reliability and quality of implementation of the plans, get the required assessment, the most sensitive to a decrease in the leading process parameters. The currently applied parameters reliability calculations often leads to inflated values, not taking into account such parameters as the reserves of time and technical resources. The reliability of the proposed calculations of reliability confirmed by statistical modeling of the influence of random processes on the basic parameters of reliability.

All factors affecting the reliability and quality of plans and schedules, can be described as a set of basic organizational and technological causes of delays and missed deadlines of works completion [15].

4. Theoretical and practical implications

Significant impact on the pace of construction, the quality and economic performance of the production level have installed power and degree of construction work mechanization. The required number of modern and efficient tunneling machines and equipment, extensive use of manual electrified tool, automation of the most complex construction processes provide a high rate of LES construction, the quality and sufficient efficiency of building production.

The process parameters define the entire process of creating building products. These parameters are:

- capital intensity of building products;
- the complexity of building processes;
- material consumption of building products;
- prefabricability of building constructions;
- level of processes technological interchangeability;
- the rate of release of building products and others.

High saturation of construction of production facilities, low labor and material consumption during creating building constructions, high prefabricability of basic elements of LES constructions provide efficiency of building production and a high rate of release of finished underground lines.

The structure the economic parameters governing the construction production, should include the cost of building products, capital-intensive construction, the payback period of the investment, the level of output per worker, and others. Organizational parameters are closely related to technical, technological and economic parameters, but at the same time they have independent value and have a significant influence on the formation of the production process. These parameters include the duration of the construction of lines, waste of time on fronts of work, waste of resources, threading the construction of tunnels and underground lines, reliability and rhythm of production.

If values of technical, technological, economic and organizational parameters are defined, provided the receipt of all necessary types of resources, the release of building products is carried out in the form of the stations and underground lines. Defined value of building production parameters form all the basic properties of building products, such as quality, durability, serviceability, efficiency and others. Many of the properties are already defined by preset values of the relevant parameters. The most important properties should include rate of issuance of finished building products, its quality and effectiveness.

Construction of LES is a complex production process, which incorporates the creation of a powerful transport complex on the basis of tunneling. This production process involves a high level specialists, installation of complex and major building structures is carried out, installation of modern and technically sophisticated power equipment is organized, a large number of construction, tunneling is involved and specific equipment is installed.

Industrialization of such construction is the main focus of technical progress in the construction of the LES. The process of construction of transport tunnels is necessary to turn to the processes in-line installation of structures and equipment, which are pre-assembled in large units by factory and specialized organizations. Such process management is possible only with the creation of a highly technological process development and implementation of management decisions.

Effective LES requires the construction of an adequate control system, having a workable governing body. The structure of the management body, in connection with the need to process large volumes of information and rapid response to changes in operating conditions, should have multiple levels. Management levels are based on the principle of the organizational chain of command and have a hierarchical structure. Management structure should take into account all the basic functions necessary to implement the management decisions. Therefore, the construction of optimal hierarchical structure of the LES construction of management is impossible without corresponding theoretical developments.

Development of of planned decisions with high reliability requires the use of the system of methods that can be divided into two areas - operational and functional. Operating methods for improvement of reliability ensure the development of planned decisions and their adjustment at the desired level of economic efficiency of building production. Functional methods aimed at preserving by management system the received level of reliability and effectiveness of planned decisions.

The system of methods and models of production management decisions can provide effective work of authority in the planning and construction management of LES with high levels of reliability. During development of methods and models of production management decisions the duration and content of the periods and LES construction stages should be taken into account. Formation of management decisions in the process of creating tunnels should take into account the state of the project development, the level of the tasks of the preparatory period and the combination of the planned phases of construction. An integrated approach to the development of management processes provides the ability to create theoretical foundations of effective management of the construction of the LES.

Thus, one of the main problems is the construction of sustainable plans and their implementation through the production system and management system at the highest possible level of economic efficiency. It is particularly relevant when creating the LES, which have significant potential for the organization of straightline construction. A flow (conveyor) the manufacturing method has the highest productivity and efficiency, and therefore construction on this based of planning and management system is very practical.

The most effective group of methods of organizing work for linear extended structuress is a group of straight-line methods. Straightline methods provide uniform and continuous production in strict compliance with the technological sequence of construction processes. The flow involves a fixed number of machines and performers that promotes uniform movement of mechanized brigades and constant release of the finished building products. In organizing the flow in time and space following options can be considered under construction underground line.

<u>Spatial parameters:</u>

- the total length of the line of the tunnel under construction;
- the length of the separate sections (bays);
- number of sections (bays);
- the number of parallel lines of the organization of production processes (private flows).

<u>Time parameters:</u>

- velocity of the private flow;
- the rhythm of each particular flow (the time of passage of each section);
- the duration of the construction of the whole tunnel line.

<u>Resource parameters:</u>

- the amount of required labor and technical resources;
- the level of rational sections saturation (private work fronts) of labor and technical resources;
- the amount of presence of labor and technical resources.

<u>Technological parameters:</u>

- total equipment-intensity and volume of work;
- specific labor and equipment-intensity of work on the fronts of private works;
- the performance of machines and specialized units and brigades;
- the number of shifts of the machines and workers per day.

In accordance with the considered parameters for the LES construction conditions and taking into account the achievement of a high level of reliability it is necessary to conduct and use a number of basic ways of work organization. According V.A. Afanasev, they include various flows with continuous (no downtime) use of resources, flows with a continuous development of scope of work and the variety of flows with the shortest periods of implementation of all the work. Flows with continuous use of resources include rhythmic, non-rhythmic flows and flows with different rhythms. Flows with continuous development of the fronts of work can also be rhythmic, non-rhythmic and with different rhythms.

Flows with the shortest periods of work implementation can be seen as flows with critical path, when each finished private scope of work is immediately mastered with free resources. These flows can be built on earlier or later date of non-critical work performance, while minimizing resource downtime or downtime of work fronts by assigning the relevant terms of the beginning and the end of the non-critical work. Flows with the critical path can be built on other principles of timing destination of non-critical work.

5. Conclusion

To improve the reliability of planning and control solutions in the construction of linear-linear you can offer different methods. These methods can be classified as institutional, technological, structural, information, management, etc. These methods in a various extent separately or in a complex may be used in the process of planning development or management decisions. In terms of building linearly-extended constructions it is possible to use the following approaches to improve indicators of reliability:

- the formation and implementation of methods of the organization of work, the most appropriate indicators for reliability;
- development of methods of the time and resources reserves creation as part of the plan and management decisions to improve the reliability level;
- forming as part of the plan and the management decisions duplicating methods of organization and technology performance of individual work complexes to ensure compliance with accepted indicators of reliability;
- building construction production management system to ensure continuous monitoring of progress and timely response to deviations from the accepted targets of reliability;
- development planning and management decisions taking into account the compensation of possible external influences to increase the level of reliability.

Implementation of these approaches for improvement of the organizational and technological reliability (OTR) requires the solution for two rather complex theoretical problems. The first issue concerns the development of ways to estimating the probability of fulfillment of planning and management decisions for specific methods of increasing reliability (method work organization received reserves of time and resources generated duplicating chains of work, management structures etc.). The second difficult problem is to assess the level of reliability in the combined use of several methods, each of which makes its own specific contribution.

An important approach of improving the reliability of implementation of LEC construction plans is the creation of reserves of time and resources. Time reserves of the works are formed by applying the method of the critical path, as well as limiting the saturation of work resources. In this case, there may be additional costs for downtime of work fronts and downtime of resources. Simple backup of both time and major resources is in most cases economically inexpedient. Search and formation of the most effective ways to create a variety of reserves from the standpoint of reliability and economy is also a rather complex task.

One of the most efficient ways to improve the reliability of the developed planning and regulatory decisions is the duplication of the most important inter-related work (chains of works). Duplication can be carried out from the standpoint of the organization of work and from the standpoint of technology of group work implementation. Dubbing fro position of organizations allows in the cases of complications, such as the scope of work, transfer manufacturing process to another chain till complications will be solved without reducing pace and reliability. From the point of view of technologies, duplicating chain of work allows to replace the technical and human resources to other systems on the other technologies also without reducing the pace of work and level of reliability.

In our opinion, the construction of a functioning management system is the most effective way to increase the level of OTR to certain values. Management allows timely adjustments to the production process, without incurring additional costs and reducing reliability. However, the construction of the corresponding control system and its operation requires a certain amount of economic costs. With the reduction of the duration of the control cycle increases the amount of costs and there is need for a comparison of arising costs and the resulting effect of reducing the costs for building production and increase reliability level.

In addition to considered ways of improving the reliability of the plan and regulatory decisions the impact of the external environment should be taken into account. The effects are random in both frequency and magnitude of the impact on the development of the production process. Manufacturing process development forecasting allows to develop the necessary measures in advance and reduce to a large extent the impact on the pace of work and the level of OTR.

Increasing the OTR in the development and implementation of design solutions requires some additional cost, but it leads to certain positive results. Additional costs arise in the field of management in the course of a detailed study of planning decisions, attraction of additional resources and regular monitoring of the production costs and operating decisions. Positive economic results appear in the field of construction industry in the following areas:

- as a rule, provision of preterm completion of the construction or complex of works;
- reduction of costs due to downtime at work and an emergency relocation of excessive labor and technical resources;

Increase in productivity of key staff and equipment; saving of materials and energy.

References

1. Gusakov A.A., Veremeenko S.A., Ginzburg A.V. Organizational and technological reliability of building./ Under reduction by Gusakov A.A Moscow: SvR-Аргус, 1994. 472 p. (rus)
2. Ginzburg A.V. Organizational and-technological reliability of construction. Coll. of articles "Systems Engineering"/ Under reduction by Gusakov A.A Moscow Foundation "New Millennium", 2002. - pp.591-608.
3. Anderson J. Minimization of risk in underground construction. // Moscow: The underground space of the world, 1998, № 5-6. - pp. 18-19.
4. Makarov I.M. Risk management. Moscow: Science, 2000.- p. 431
5. Iakubaitis E.A. Information networks and systems. Moscow: Finance and statistics, 1996. - 368 p.
6. Ohrimenko S. A. Modern problems of improving information management service processes. Moscow: "Automation and modern technologies", 1993, №. 1. - pp. 26-28.
7. Brodin Arne. Risk analysis and safety concept, Norra and SodraLanken (Chosen and the Southern Link). Underground Construction in Modern Infrastructure. Rotterdam, Balkema, ISB № 9054109645 – 1998. – pp. 25-31.
8. Hanagud S., Uppolusi B. Reliability-based optimum inspection and maintenance procedures/J. Aircraft. 1975.-v. 12, no. 4. -P. 403-410.
9. Hergenroder M., Sshall G., R Rackwitz. Reliability and risk function for deteriorated structures. Durability of structures. JABSE Symposium, Sept. 6-8, 1989, Lisbon. CH-8093, Zurich. - 1989. – P. 511-516.
10. Smith, R.J. Risk Management for Underground Projects. Cost-Saving Techniques and Practices for Owners, Gallerie, 1994. -pp. 42-56.
11. G. Augusti, A. Baratta, Kashiati F. Probabilistic Methods in building design. / Transl. from English. U.D. Suhova. Moscow Stroiizdat, 1988. - 584 p.
12. Bezrukova T.L. Technical and economic analysis of the enterprise. Moscow EKMOS, 2002. -199p.
13. Egoshina O.A. Technical and economic analysis of efficiency of fixed assets use. Дис. ... к.э.н. St. Petersburg: 2004-222 p.
14. Abdullaev G.I. Comparison of methods and models for short-term forecasting of organizational and technological processes of LEC construction. Coll. "Methods and models of design and management in construction." Moscow Russian Engineering Academy - Moscow State Civil Engineering University, 2001. - pp. 16-18
15. Gnedenko B.V., Belyaev J.K., Solovyov A.D. Moscow: "Science", 1965. - 524 p.