



BASES OF QUALITY MANAGEMENT OF CONSTRUCTION AND REPAIR OF HIGHWAYS

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Abstract. Modern problems in the field of quality of the road infrastructure, the structure and quality of the existing road infrastructure in Byelorussia and problems of its perfection are analysed, some ways of maintenance of high quality on the basis of substantive provisions of the theory of quality management of highways are also offered in this article.

Keywords: quality of highways, maintenance of highways quality, quality management, monitoring of quality management processes.

1. Introduction

Dynamical development of the modern society has generated a new treatment of quality problems. Thus the philosophical aspect of the problem of quality is even more often considered, the attention of the society is focused on the quality of human life. Orientation to scientific and technical progress, construction of models of an industrial society are replaced by the concept of steady development of the society. Quality of human life is defined as the purpose of world development.

Huge social and economic value of the road infrastructure for maintenance of a high degree of quality people's life is obvious. It is especially actual for Byelorussia occupying a specific geopolitical position "on crossroads" of the Europe.

For our state the main things are transport corridors: the West – East (No 2) London–Berlin–Warsaw–Moscow–Nizhny Novgorod–Yekaterinburg, and the North – the South (No 9) Helsinki–Petersburg–Kiev–Odessa–Kishinev–Bucharest.

The Belarus roads became a part of the European routes, intensity of movement on which already today reaches about 30 000 cars per day. On the roads of our state 84 % of all cargoes and 53 % of passengers are carried by the motor transport. It essentially lifts a lot of requirements to national highways which, being a part of the European transport system, should correspond to modern standards quality of maintenance.

The concept "quality of the road", as well as, in general, "quality" is not monosemantic.

Quality as technical category is a priority property by all engineering development. The level of quality of highways is laid before the start of designing the conceptual decision, provided during the design, formed at construction and shown while in service. Absence of the complex approach leads to impossibility to solve the problem of maintenance of the object's quality, and also the service quality, given to the consumer. From the technical point of view it is accepted to use various criteria of quality of highways. The most important of them are durability of road clothes, flatness of a road covering, engineering arrangement, technical parameters of all road structures and their condition as a whole.

By consideration of quality as an economic category it is necessary to have in mind that improvement of quality assumes significant economic expenses. At the same time, improvement of quality of production and services provides an economic benefit to the consumer due to reduction of a number of refusals, increase of operational reliability, a reduction of charges because of road accidents, reductions of power consumption etc. The level of quality should be economically proved as the highest quality can cost much and will not pay back by reduction of service expenses.

Quality as a social category should be connected with correct formation of ideas of the manufacturer and the consumer. For the present stage of social production a sharp

increase of attention of manufacturers and consumers to quality of the presented production and services is characteristic.

Now for an estimation of quality of highways various systems, methods and devices which allow to estimate some parameters “physically” are used, and others – to classify. Complexity of definition of the “quality of a highway” consists also in various demands for roads of various types and purposes on quality. Even the same road at various times of the year or the periods of operation has essential distinctions in qualitative characteristics.

The present article is devoted to the problems of maintenance of highways quality at the construction stage. From the technical point of view, it is accepted to use different criteria of quality: durability of the design of road clothes, flatness of the road covering, engineering arrangement, technical parameters of all road constructions and their condition as a whole. The system of an estimation of highways quality in modern condition represents a highly developed monitoring system which results of estimation are used in maintenance and repair of roads, in the traffic management, in definition of the investment policy. But the given system does not allow to operate by the process of quality, to make monitoring of the managerial process, to influence the end result.

2. The control and maintenance of highways quality

A high level of quality is reached only when at each stage, from the design up to finishing adequate works, an adequate policy in the field of quality is being maintained.

Such a policy contains general intentions and direction of activities officially formulated by the top management. Intentions can remain intentions if a technical competence of the manufacturer is absent.

An estimation of competence in road management is difficult. For example, in the Russian Federation till 2002 this procedure was carried out within the limits of licensing which has been assigned on “Rosavtodor”. Since 2002 licensing in the road branch of Russia is not performed on the basis of the Law of the Russian Federation “About licensing separate kinds of activities”, but organs of management by the road industry should enter the objects of road works only for technically competent organisations. It is possible only by developing and introducing in action the system of an estimation of competence of road works manufacturers.

Now in the Russian Federation the system of an estimation of conformity of the test laboratories in the road industry and the building industry operates (Fig 1) [1]. Works on creation of the system of an estimation of technical competence of contractors are performed. In Byelorussia

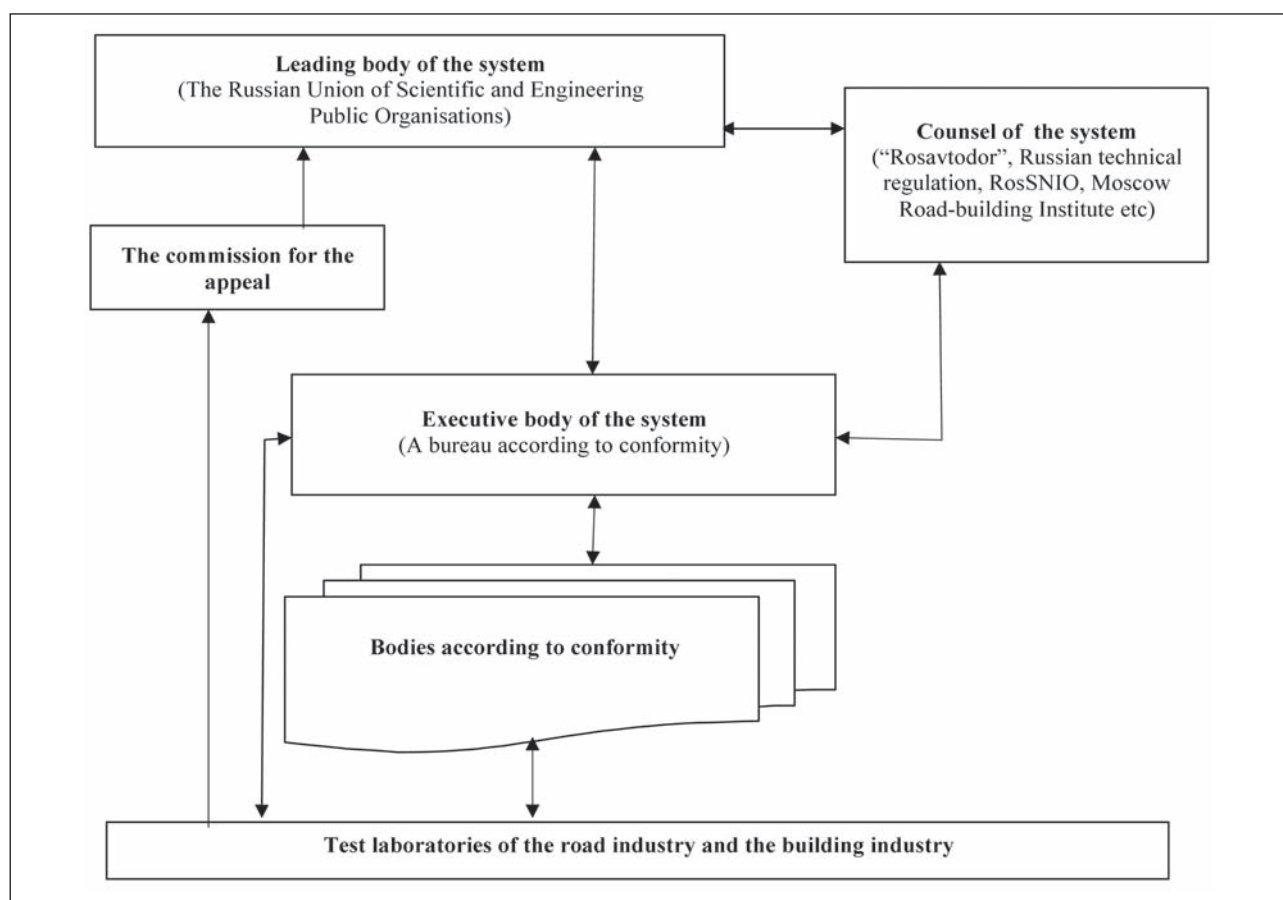


Fig 1. System of an estimation of conformity of test laboratories in the road industry and building industry

the system of licensing the contract organisations for certain kinds of works and accreditation of the systems of a quality management of standard ISO 9000 and ISO 14000 operates now.

Under the certificate of Henshe and Wiskers: “a lot of the road organisations or already uses the system of maintenance of quality ISO 9000 (as FinDA and Rijkswaterstaat in the Netherlands), or acceptance of the given systems (Transit of New Zealand) is in process, or have made a decision to use a partial system of maintenance of quality, which does not necessarily coincide with standards ISO 9000 (state of Maryland in the USA)” [2].

In this case “the partial system of maintenance of quality” is the so-called “the system of partnership”, which is closely connected with planning and manufacture, especially when the project makes negative influence on the environment and, hence, has a smaller support of local inhabitants. From the organisational point of view, the system of partnership represents carrying out of a specialised seminar with participation of all interested parties.

By road-building, repair work and works connected with the maintenance of highways it is expedient to use the

three-level control (Fig 2). The internal control is for brigades of workers and everybody accepting direct participation in performance of works; it basically consists in realization of the regular and systematic control on a construction site, and skilled, serious and competent staff which understands its necessity for maintenance of high quality of work. For example, making the asphalt and concrete coverings includes checking temperature of asphalt-concrete mixture, levels and adjustment of the levelling adaptations of an asphalt spreader, thickness of a layer, speed of an asphalt spreader etc, and is carried out by the foreman, the operator of an asphalt spreader and the controller of the levelling bar; the external control concerns “the policy of quality of the company”, as well as the internal control. It is completely included into the competence of the enterprise and serves as any kind of the necessary control over normative requirements. It should be as more as possible independent from a working brigade; it is usually carried out by a specialised laboratory. For example, in making the asphalt and concrete coverings the external control is carried out by the laboratories for checking condensation, design slopes etc; the external control consists in necessity of

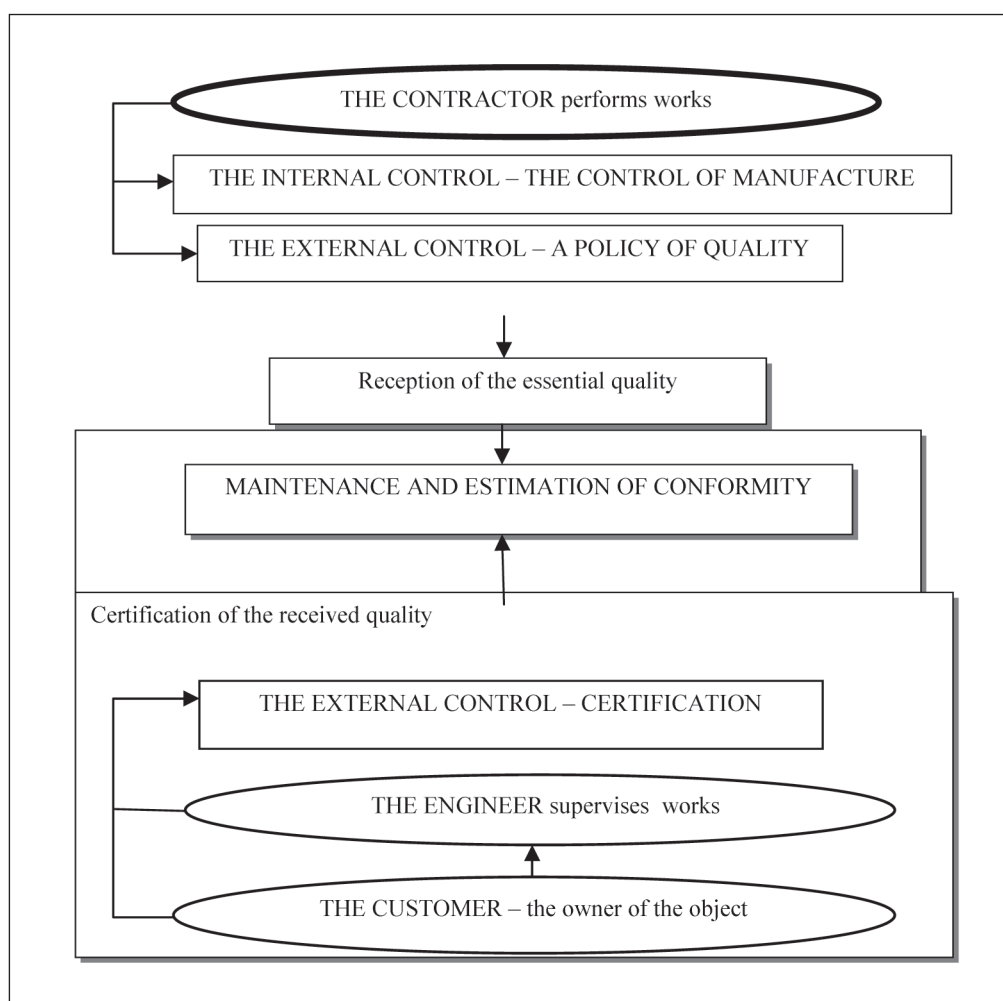


Fig 2. Three-level quality control

supervision, which is carried out directly by the customer.

The sides in the control system of quality are: the customer (employer), for example, the ministry of transport; the engineer, the representative of the management of roads or a specially appointed department; the contractor responsible for performance of works.

3. Regulation of the quality level

Next situation of the USSR was typical: standardisation established “the top lath” in requirements of corresponding state standards that not always reflected the most advanced level of achievements in some spheres of science and technology, did not stimulate the achievement of high quality, decrease in cost price, and increase in competitiveness of the domestic enterprises.

Abroad the level of national standards establishes “the bottom lath”, ie minimal-admissible norms, to which there should correspond the production to get to the market. Further firms-manufacturers let out their corporate standards in which the level of quality of production is established higher, that promotes an increase in its competitiveness (Fig 3) [3].

Between lines of minimal-admissible norms (the minimum level of quality of life) and the line of the requirement of corporate standards (the line of the level of quality offered on the market) is a zone of a competition.

Now in the Russian Federation, for example, in connection with transition to technical regulation a new category of norm-legal certificates – technical regulations in which requirements to quality of production are set in two ways [3, 4]: directly by detailed (concrete) values of parameters; by the general requirements qualitatively defining a necessary level of safety.

It is considered that the first way of setting up requirements to production is expedient for using if: for production which is under action of the technical regulation, there is no demonstrative basis in the form of national standards corresponding to the given regulation; the level of harmonisation of the national standards with the international ones is insignificant and, on their basis, the necessary level of quality is not provided; the state is interested in realisation of the uniform technical policy expressed in the setting up concrete requirements on quality of production, extending a concrete segment of the market.

The second way of setting up requirements is connected with an establishment of the general qualitative requirements which can be considered as norms of law (the technical regulation is accepted as the Federal law or the governmental decree of the Russian Federation). Experts consider that in this case it is necessary by development of the technical regulation to make the analysis of: directives of the EU and technical regulations of other countries in this area; the international standards; national standards which extend to production which is under the given technical regulation; normative documents of the executive state power which establish requirements to separate properties of production under the technical regulation action.

Besides, under conditions of technical regulation the principle of voluntariness is cultivated. The principle of voluntariness of application of the standard's norms can be formulated in an other way: in the European documents, voluntariness is designated more correctly: it is recommended to application. If you have come to work to this or that branch, everything what is recommended for this sphere, it is necessary to execute entirely.

“In the USA, for example, where standards are voluntary, in case of legal proceeding at infringement of the con-

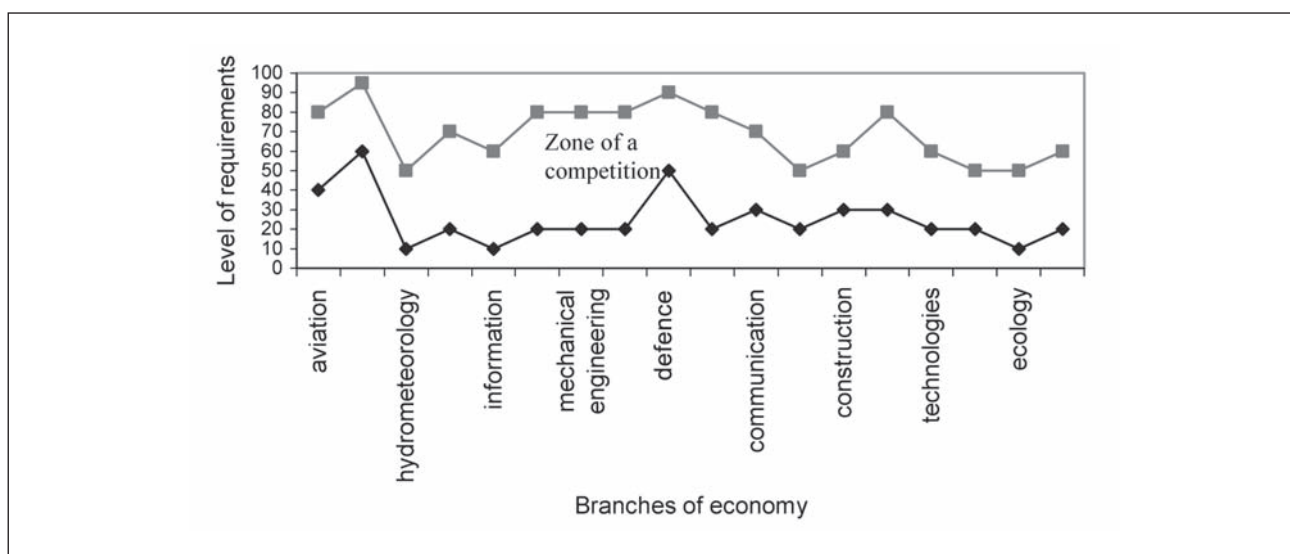


Fig 3. Normative bases of the competition

tract courts ascertain: the given firm has neglected the national standard. And since this moment any organization will not conclude with it any contract. Here thus the market adjusts partner relationships” [5].

4. Technological processes of construction of highways in the “life cycle” of highways

Standard ISO 9004 instructing on maintenance of quality defines interaction on each phase of the “life cycle” of the goods. This schedule covers all kinds of activities. Its purpose is to show that introduction of the system of quality conducts to definition and reconsideration of a role of the organization as a whole. Specificity of transport projects consists in a long duration of the “life cycle”, which also

increases efficiency of using control systems of quality with reference to highways.

Scientists of the Moscow Road-building Institute (the State Technical University) suggest considering a logic and functional communication between all stages of the life cycle of highways according to the scheme presented in Fig 4 [6].

How to measure quality of technological processes at the stage of construction of highways? Practically it is measured by performance of the long list of tests in laboratory or on the road, but these kinds of the control do not check “quality” of the road, they only allow to measure some characteristics which estimate it. Besides, these measured values are not identical to all countries, a country has different

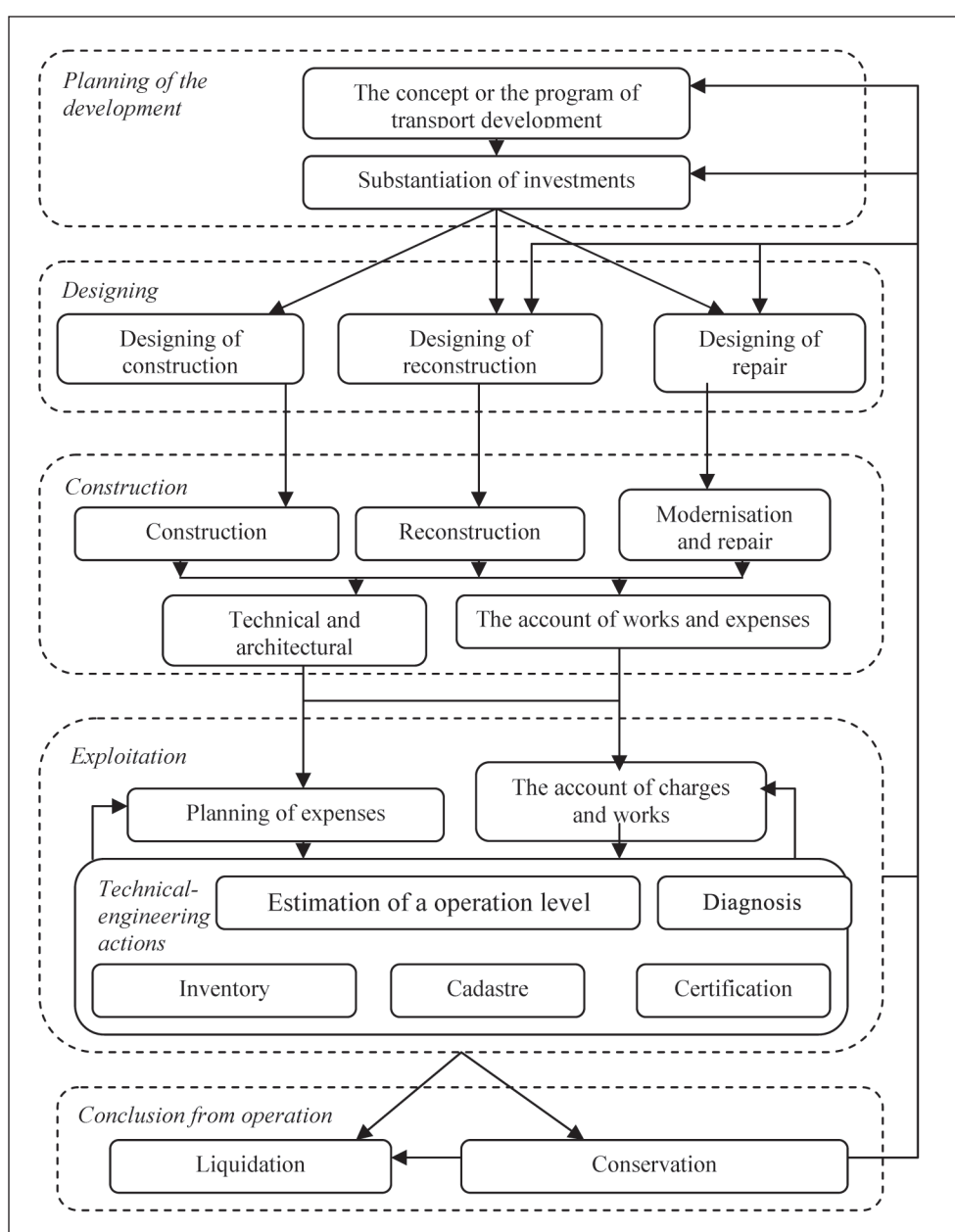


Fig 4. Typical phases of the “life cycle” of a highway

criteria. And for the same places obligatory requirements can be different because of distinctions of the climate, operating conditions of a highway and local conditions. Existing in the sphere of road construction measured characteristics are not universal.

P. P. Petrovich [6] suggests to consider technological processes of construction of highways from the point of view of the system analysis, as organisational-physical aggregate of the technological subprocesses, described by a purposeful change of properties of materials. Besides, it is offered to consider development of technological processes in the form of “changing streams of substance (S), energy (E), information (I) and the finance (F), which are interconnected with a simplex-diagram of components” of the transport process as a uniform developing system.

According to the offered method, at each stage of technological process it is possible to define structure and to calculate quantitatively streams of substance, energy, the information and the finance for various variants of manufacture of works, and to find the most rational variant of technology by a criterion of optimisation.

In this case the stream of substance consists of materials, machines and people streams. The stream of energy consists of mechanical, thermal, chemical, electric, intellectual, mental energy and other power streams; the stream of the information includes streams-signals: sound, light, graphic etc. The stream of the finance: volume of money of own capital, the credit (investment), expenses for manufacture (cost of materials, machines, salary), profits, percents for the credit, cost of realised production, taxes etc.

In connection with the above-stated, quality management of technological processes of construction of highways is necessary for carrying out according to the sub-

stantive thesis of the theory of technological processes offered by P. P. Petrovich.

In this case presentation of the process in the form of “a black box” (in the theory of quality management), which transforms inputs into outputs (Fig 5), it is possible to interpret representation of process by describing the technological processes in construction of highways.

Monitoring of technological processes in this case should also be taken into account according to the process approach.

Operating in Byelorussia, STB ISO 9000-2000 is intended “to induce acceptance of the process approach to management of the organisation” [7]. It is possible to illustrate (Fig 6) using the process approach in systems of a quality management [8].

According to the given theory, for each stream of technological process (material, energy, information, finance) should be developed by the objective criteria, allowing to carry out monitoring and to estimate efficiency of process performance. Criteria of monitoring will have different physical, economic and other meaning, different units of measure, but they will allow to estimate a situation objectively.

Such criteria will allow to construct not the monitoring system of quality, but a system of maintaining quality.

The purpose of construction of the system of quality maintenance is forecasting possible problems: for elimination of many reasons of mistakes; for defining measures and means of elimination of possible defects; for creation of independent structure of a quality control.

Absence of defects is the purpose, but not an expected result; improvement of production quality at each stage will improve a situation, but it is necessary to be ready to the

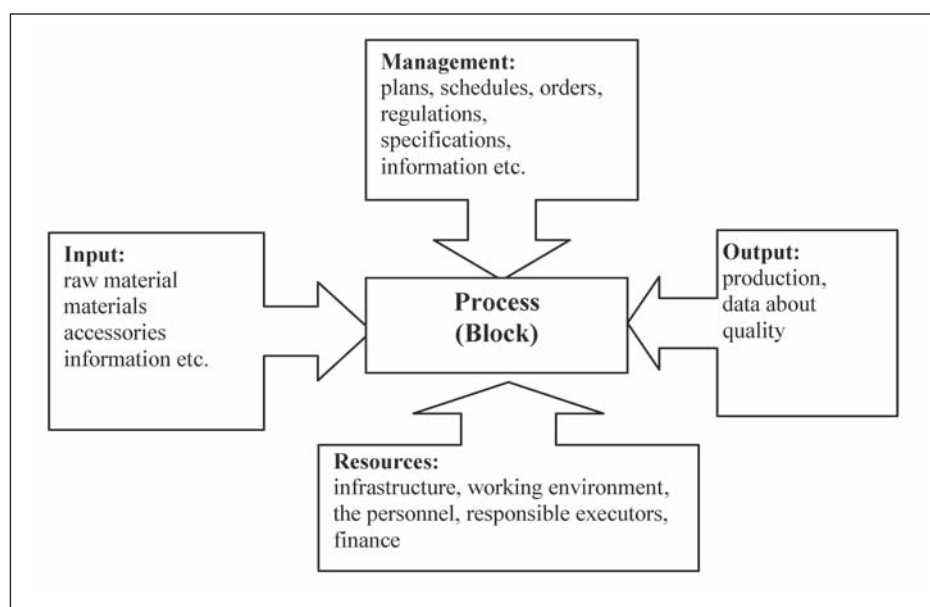


Fig 5. Typical elements of the process

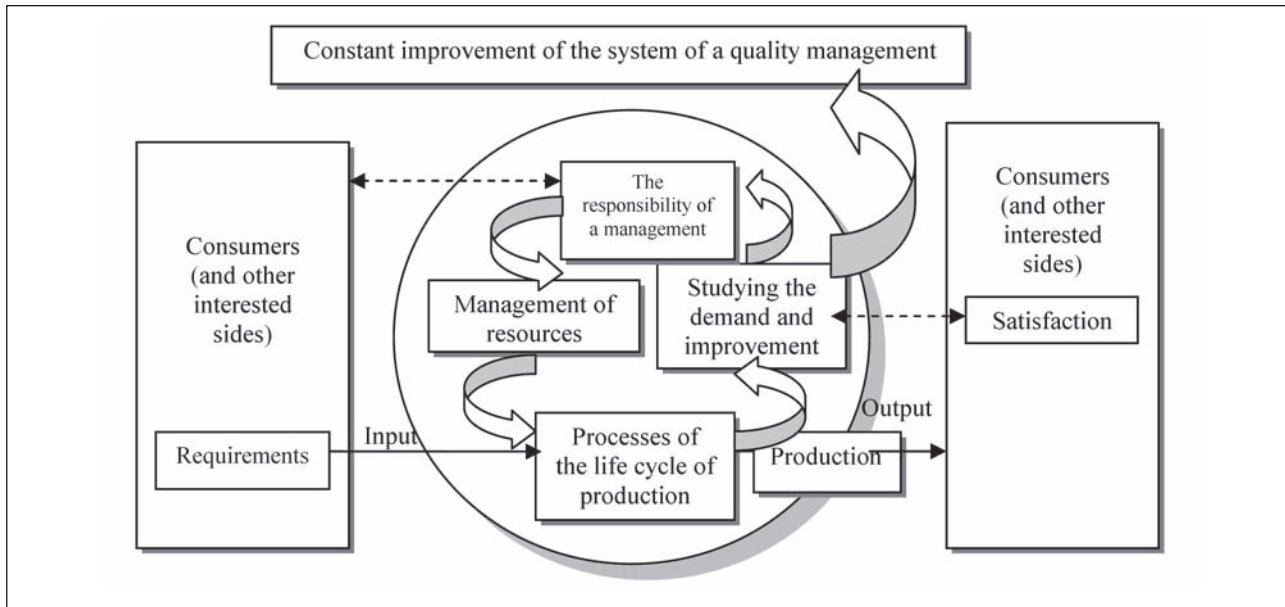


Fig 6. Model of the system of the quality management based on the process approach

solution of some inevitably arising problems or, at least, to provide ways of eliminating defects. The majority of defects should come to light by a production team, though the independent supervised structure which does not accept a direct participation during manufacture should be necessarily created.

5. Criteria of monitoring the technological processes in road building

In the process of development of the concept of quality management by highways we offered a matrix of management [9]:

$$U = \begin{bmatrix} u_{ss} & u_{st} & u_{so} \\ u_{ts} & u_{tt} & u_{to} \\ u_{os} & u_{ot} & u_{oo} \end{bmatrix}, \quad (1)$$

where u_{ss} – the problems of strategic management solved at a strategic level of hierarchy; u_{st} – the problems of tactical management solved at a strategic level of hierarchy; u_{so} – the problems of operative management solved at a strategic level of hierarchy; u_{ts} – the problems of strategic management solved on a tactical level of hierarchy; u_{tt} – the problems of tactical management solved at a tactical level of hierarchy; u_{to} – the problems of operative management solved at a tactical level of hierarchy; u_{os} – the problems of strategic management solved at an operative level of management; u_{ot} – the problems of tactical management solved at an operative level of hierarchy; u_{oo} – the problems of operative management solved at an operative level of hierarchy.

Considering problems of monitoring of managerial processes by quality of highways at different management

levels, it is necessary to notice that the major element of monitoring of any process are the criteria, allowing actually the control (estimation) of this or that process.

Analysing monitoring of managerial processes by quality of highways at strategic, tactical and operative levels, it is necessary to note that criteria of estimation for different levels of management will be different too.

By analogy to a matrix of management it is possible to make a matrix of criteria which should be applied to monitoring during quality management of highways at different levels of hierarchy [8, 9].

$$K = \begin{bmatrix} k_{ss} & k_{st} & k_{so} \\ k_{ts} & k_{tt} & k_{to} \\ k_{os} & k_{ot} & k_{oo} \end{bmatrix}, \quad (2)$$

where k_{ss} – criteria for monitoring of quality management processes at a strategic level at the solution of strategic problems; k_{st} – criteria for monitoring the quality management processes at a strategic level at the solution of tactical problems; k_{so} – criteria for monitoring quality managing processes at a strategic level when treating operative problems; k_{ts} – criteria for monitoring the quality managing processes at a tactical level when solving strategic problems; k_{tt} – criteria for monitoring the quality managing processes at a tactical level when solving tactical problems; k_{to} – criteria for monitoring the quality managing processes at a tactical level when solving operative problems; k_{os} – criteria for monitoring quality managing processes at an operative level of strategic problems; k_{ot} – criteria for monitoring quality managing processes at an operative level when solving tactical problems; k_{oo} – criteria for monitoring quality managing processes at an operative level.

From the point of view of quality maintenance of technological processes in road building, we are interested in a group of criteria: k_{os} – criteria for monitoring quality managing processes at an operative level when solving strategic problems; k_{ot} – criteria for monitoring quality managing processes at an operative level when solving tactical problems; k_{oo} – criteria for monitoring of quality managing processes at an operative level when solving operative problems.

Criteria for monitoring of an operative level of management by technological processes of constructing of highways can be presented in the form of:

$$K_o = \begin{bmatrix} k_{os} \\ k_{ot} \\ k_{oo} \end{bmatrix}. \quad (3)$$

Perfection of a control system by quality of highways can be carried out in directions which are defined by factors of influence on controllability of the system [9]: economic, financial, scientific-technical (engineering), organisational; social factors.

Thus criteria for monitoring managerial processes by quality of highways at all levels of hierarchy of management can be classified into such analogies: economic, financial, engineering, organisational and social ones. According to the offered classification of criteria of monitoring managerial processes by quality of highways, it is possible to offer classification of monitoring: economic [5], financial, engineering, organisational and social monitoring.

At the same time for monitoring technological processes it is possible to use the system of the criteria representing an aggregate of criteria for estimating the change of streams of substance (S), energy (E), information (I) and the finance (F) during the technological process realisation:

$$\begin{cases} k_{os} = [k_{os}^e, k_{os}^3, k_{os}^u, k_{os}^f], \\ k_{ot} = [k_{ot}^e, k_{ot}^3, k_{ot}^u, k_{ot}^f], \\ k_{oo} = [k_{oo}^e, k_{oo}^3, k_{oo}^u, k_{oo}^f], \end{cases} \quad (4)$$

where $k_{os}^e, k_{os}^3, k_{os}^u, k_{os}^f$ – criteria of changing the monitoring of streams substance, energy, information and the finance when solving of strategic problems of an operative management level technological process; $k_{ot}^e, k_{ot}^3, k_{ot}^u, k_{ot}^f$ – criteria of changing monitoring of streams of substance, energy, the information and the finance at the decision of tactical problems of an operative management level of technological process; $k_{oo}^e, k_{oo}^3, k_{oo}^u, k_{oo}^f$ – criteria of changing the monitoring of streams of substance, energy, the information and the finance at the solution of operative

problems of an operative management level of technological process.

It seems possible to construct systems of the equations for criteria of management monitoring of technological processes in road building for a strategic and tactical level of hierarchy of management in the road branch.

The choice of concrete criteria will be defined by laws of interaction of different streams (substance, energy, the information and the finance). Such an interaction submits to requirements of certain laws (for example, streams of materials cooperate among themselves according to laws of mechanics of the continuous environments and mechanics of discrete materials, physical and chemical mechanics; streams of people cooperate among themselves by sociological, psychological, public etc laws; streams of machines – by organisational-technological laws; interaction of machines and materials – according to laws of mechanics of destruction, the theory of condensation; people and machines cooperate on the basis of the theory of management, the theory of games etc; interaction of streams of the information – on the basis of cybernetic positions; interaction of financial streams – on the basis of the theory of cost; interaction of different kinds of energy – on the basis of laws of thermodynamics, transformation of energy etc).

“Interaction of financial streams and streams of substance, energy and the information is carried out on the basis of theories of market economy, in particular theories of balance: money – technical progress – employment” [6].

6. Conclusions

1. Successful performance of important social-economic problems of maintenance of a high level of quality of life depends on quality of the road infrastructure.

2. Quality of the road infrastructure is characterised not only by technical parameters, but also by ecological and social-economic ones.

3. Primary problem of workers of the road branch is maintenance of technical quality of highways which is defined in the conceptual decision before designing process begins, provided during designing, formed at construction and shown while in service.

4. Today's control systems of quality of highways are based on production quality control.

5. Modern level of development of manufacture and level of the needs of consumers demand construction and development of systems of quality maintenance which purpose is forecasting probable problems, instead of an establishment of the fact of a deviation from a fixed level of quality.

6. On the basis of the control system of quality of construction and repair of highways principles of the process approach to product quality control should lay.

7. According to the theory of technological processes,

quality management of construction and repair of highways should be carried out on the basis of the criteria received by results of economic, financial, engineering, organizational and social monitoring of managerial processes.

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