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SOME QUALITY MANAGEMENT ISSUES OF ROAD CONSTRUCTION

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Abstract: *The article addresses issues related to improving quality in the construction, reconstruction, and major repair of roads. It focuses on ensuring high quality at every stage of road construction, proper organization of control mechanisms, and increased accountability of all participants in the process (the client, contractor, supervisory bodies, etc.). The article emphasizes that road quality is influenced by a wide range of factors, including the physical and mechanical properties of materials used, applied technologies, the professionalism of specialists, climatic conditions, and even organizational aspects of the work - all of which directly affect the final outcome. In this regard, quality is not merely the end result of construction but a product of proper management and a systematic approach at all stages. Furthermore, the article provides a detailed review of the stages of quality control implementation. This control is aimed not only at eliminating defects but also at identifying their root causes and developing scientific and technical solutions to prevent their recurrence in the future. In other words, the approach emphasizes proactive rather than reactive quality management. Creating modern and durable roads requires a comprehensive approach from technical, organizational, and economic perspectives. The concept of quality is not limited to the smoothness or strength of the pavement - it also includes indicators such as safety, environmental sustainability, low maintenance costs, and overall travel comfort.*

Thus, the article provides readers with a broad perspective on improving quality in road construction - not only from a technological standpoint but also from managerial, planning, and scientific perspectives. The goal is not merely to build a good road but to develop a durable, safe, and economically efficient road infrastructure.

Keywords: *highways, construction control, quality of road construction, economy in road construction*

1. INTRODUCTION

Improving the transport and operational quality of highways is today one of the main tasks facing both engineers and society. A road is not just an asphalt surface - it is the circulatory system of the economy. A good road ensures fast, safe, and comfortable transportation of goods and passengers. A poor-quality road leads to the rapid wear and tear of vehicles, increased fuel consumption, loss of time, and most dangerously, a rise in the number of traffic accidents.

The issue of quality control during the construction, reconstruction, and major repair of highways is of paramount importance. Proper selection of high-quality construction materials, adherence to technological requirements, and competent use of modern machinery ensure the reliability and durability of roads in the future. For example, if the road base is poorly constructed, within a few years cracks, subsidence, and signs of deformation will appear on the asphalt surface. This not only mean a loss of quality and economic damage but also poses a threat to traffic safety.

Improving the quality of roads in operation is not only a technical issue but also an organizational and managerial one. Constant monitoring of road conditions, regular inspections, the collection and analysis of pavement condition data are essential for the effective functioning of the transport infrastructure. Based on these data, sections requiring repair are identified, and materials demonstrating the greatest durability are selected.

In the modern era, the introduction of innovations plays a significant role. New generations of asphalt mixtures, environmentally friendly and sustainable materials, automated control systems, and roads equipped with sensors are already being actively tested in many countries. Such technologies not only increase the service life of roads but also enable their "smart" management. Research is being conducted on road surfaces capable of adapting to temperature changes and traffic loads.

Improving the transport and operational quality of highways is not merely an engineering challenge but a strategically important area from economic, social, and environmental perspectives. Every investment in road quality contributes to the long-term development of the country and to traffic safety.

This topic will continue to grow in importance, as maintaining resilience and modernizing roads amid increasing traffic volumes and climate change become ever more difficult - yet all the more necessary.

1. ROAD QUALITY

The quality of highways is an indicator of the level of a country's transport infrastructure. Good roads ensure safe, comfortable, and uninterrupted traffic flow, strengthen economic ties, and stimulate regional development. Such quality does not arise by chance - it is the result of the proper interaction of many factors.

First, the ***regulatory and technical framework*** of the road industry plays an important role is played by. The more precise and up-to-date the national standards, norms, and rules for road design, construction, and operation, the higher the achievable quality. If these standards are outdated and fail to account for new technologies, even a road built with the best materials will deteriorate quickly.

Second, the ***quality of design and estimate documentation*** is of great significance. Without a sound project, it is impossible to build a quality road. The project must take into account the route, terrain, climatic conditions, the roadbed structure, traffic intensity, and many other factors. Errors at this stage inevitably lead to problems after the road is put into operation: asphalt cracks, water accumulates, and subsidence and deformations occur.

The third important factor is the ***quality of materials*** used. Asphalt concrete, cement concrete, crushed stone, sand, and other materials must comply with national standards. Using

low-quality or cheap materials may provide short-term savings but leads to major losses in the long run, because such roads require repairs within just a few years, creating an additional burden on the budget.

One of the most crucial conditions is ***using modern technologies in road design and construction***. For example, computer modeling, geographic information systems (GIS), drone-based inspections, automated asphalt-laying technologies, and sensor-based monitoring systems are being actively implemented in many countries. These technologies reduce the number of errors, optimize material consumption, and improve the overall quality of construction.

Equally important is the ***use of modern road-construction machinery***. Old equipment cannot provide the precision and quality required today. New machines work more accurately, efficiently and distributing materials more evenly. Modern asphalt pavers can ensure an ideally smooth surface with millimeter-level precision, which significantly increases the road's durability.

However, even the most advanced machinery will not guarantee success without the ***human factor***. Without qualified engineers, technicians and workers no project can achieve the desired result. Experienced specialists can identify risks in advance, select appropriate materials, and control quality at every stage of the process.

Finally, without an ***effective quality control system,*** all efforts may be in vain. Control must be exercised at all stages - from design to operation. Quality indicators should be measured, documented, and analyzed. Such a system must function at both the technological and administrative levels.

Road quality is not just about asphalt thickness or surface smoothness; it indicates the coordinated work of an entire system. Only by maintaining balance and interconnection among all factors roads can become durable, safe and comfortable. This is a true sign of engineering professionalism and management culture.

2. SYSTEM OF OPTIMAL QUALITY CONTROL

The system of optimal quality control is the main mechanism ensuring the reliability, durability, and safety of highways - during construction and throughout their operation. This system is an "intelligent observer" of the construction process, monitoring the accuracy of work at every stage. A well-structured control system is needed not only to eliminate errors but also to understand their causes in order to prevent their recurrence in the future.

This system consists of four main stages: ***preliminary***, ***operational***, ***acceptance*** and ***supervisory***. At the ***preliminary stage***, project documentation, materials and technologies are inspected, it is meaning that compliance with established standards is confirmed even before construction begins. At the ***operational stage***, the condition of existing roads is evaluated: cracks, subsidence, deformations and other surface defects are identified. The **acceptance stage** includes

checking the quality of a newly built or repaired road, conducting laboratory tests and documenting the results. The ***supervisory stage*** coordinates all these processes and ensures the stable functioning of the overall quality system.

Today, the existing quality control system in the road industry yields certain results but does not fully meet modern requirements. This indicates the need to update methods and approaches. Scientific and technological progress is advancing rapidly and control mechanisms must keep pace with it. For example, modern technologies make it possible to detect pavement defects in real time using thermal imaging cameras, laser scanners and specialized sensors. This reduces dependence on the human factor and makes assessments more objective.

An optimal control system should not be limited to technical inspections alone. Its main task is to analyze the causes of defects and propose scientifically justified measures to prevent their recurrence. For instance, if cracks appear on the same section of road every year, the problem is likely not with the material quality but with design errors or drainage system issues. In such cases, the control system must not only record the defect but also suggest an engineering solution for its elimination.

Moreover, this system must be grounded in legislation. The laws “On Highways” and “On Road Traffic” define the standards for quality, safety and operation. The optimal control system serves as a tool for implementing these requirements in practice. It ensures compliance with state standards while simultaneously protecting the safety of road users: drivers, passengers and pedestrians.

In recent years, Azerbaijan has made significant progress in road construction. Modern equipment, new technologies, and high-quality materials are being used in many projects. But these innovations do not always deliver the expected results. The main reason lies in the insufficiently effective planning and organization of quality control at all construction stages.

For example, in an effort to complete projects quickly, contractors sometimes violate technological requirements. This often happens in summer when asphalt concrete is laid at excessively high temperatures without proper cooling, or during rainfall when earthworks are carried out. In such cases, the road may appear high-quality at first glance but soon develops cracks and deformations after commissioning. This leads not only to financial losses but also to decreased traffic safety.

To avoid such problems, ***laboratory control*** must be carried out at every stage of construction and repair. All materials, such as asphalt concrete, cement concrete and soil base must be tested for compliance with physical and mechanical standards and the results recorded in official reports. After each stage, inspection certificates are prepared and archived so that the causes of future defects can be identified if necessary.

A well-designed quality control system is a “health passport” for the road. It allows not only for tracking its current condition but also for preventing potential problems in the future. Such a system increases the service life of roads, reduces maintenance costs and most importantly, enhances traffic safety.

In fact, a modern control system must be capable of “seeing” not only the surface of the road but also its internal condition. This is possible only through the integration of technology, science and professional expertise.

3. ENSURING THE QUALITY OF HIGHWAYS

Ensuring the quality of highways is a main goal aimed at maintaining their reliability, durability, and safety. This process is not limited to construction work alone; it also includes the stages of planning, control, evaluation, and final acceptance. Quality control can be described as a kind of “insurance” for the road - a mechanism that confirms all work is carried out in accordance with state standards and technical requirements.

This control should be carried out by accredited government agencies, experienced experts, or consulting organizations that hold the appropriate licenses. These entities do not interfere with the construction process itself but ensure that each stage of the work is performed correctly and complies with standards. Essentially, their role combines that of a “judge” and an “observer” - they provide an objective, fact-based assessment.

Quality control is carried out in three main stages: ***before the start of construction***, ***during construction***, and at the ***final stage***. Each of these stages has its own functions and objectives.

1. Pre-construction stage. This stage covers the preparatory period. For construction to begin properly, all stakeholders - the client, contractor, engineers, and technical inspectors - gather and present the project. During this meeting, the boundaries of the construction site, the types, volume and technological sequence of the work are determined.

It is also important in advance to coordinate the forms of quality control with the client. It is determined the methods of quality measurement, what indicators to be monitored, who and when will conduct the check. Specialists familiarize themselves with the design and technical documentation and assess the accuracy of geodetic work. Everything at this stage must be meticulously planned, because the quality of preparation largely determines the success of the subsequent steps.

2. Construction work stage. This stage can be called the “heart of the process,” because all construction and installation operations take place. The role of control agencies and experts is to ensure that these works are performed correctly and to the required quality standards.

At this stage, the completeness and accuracy of the technological documentation and design regulations are checked. All plans, diagrams, technological sequences, and methods used must comply with the established rules.

Next is the incoming inspection of materials and structures. For example, asphalt concrete mixtures, concrete mixtures, reinforcing steel, and other materials delivered to the site undergo laboratory testing. If materials are of low quality or do not meet standards, their use is strictly prohibited.

Simultaneously, operational monitoring of the construction progress is being carried out. Specialists perform on-site inspections at every stage to ensure that the actual work corresponds to the construction schedule. In cases of delays or violations of the technological sequence, an appropriate report is prepared.

Special attention is paid to “hidden works,” such as the preparation of the soil layer, installation of drainage pipes, and similar tasks. Since these elements become inaccessible for inspection after the asphalt layer is laid, specialists must be present on-site at this stage and prepare an inspection report.

In addition, photographic documentation is conducted - each stage of construction is recorded through photographs. This becomes valuable evidence both for reporting purposes and for any subsequent technical expertise.

3. Final stage. After the completion of construction works, a final evaluation is carried out. All materials, reports and test results are collected and handed over to the client in accordance with the technical specifications.

A preliminary diagnostic of the constructed road section is carried out - the evenness of the surface, adhesion level, pavement strength and other indicators are measured. The working and acceptance commissions visit the site, inspect it and prepare a final report based on their findings. This report includes a list of accepted works, identified defects and recommendations for their elimination.

The process does not end even after the road is put into operation. During the warranty period, technical monitoring of its condition is carried out. If cracks, damages or deformations appear, these cases are recorded and the contractor is obliged to correct the defects at their own expense.

Ensuring road quality is a multi-stage, systematic and scientifically grounded process. The goal of each stage is not merely to “control” but to improve the result. With this approach roads become more durable, public funds are used efficiently, and most importantly citizens benefit from safe and comfortable driving conditions.

A good road is not just a strip of asphalt concrete, it is a reflection of responsibility, professionalism and discipline.

4. COMPREHENSIVE QUALITY MANAGEMENT SYSTEM FOR ROAD CONSTRUCTION WORKS

Comprehensive quality management system for road construction works is a unified and well-designed mechanism that ensures the preservation, control and continuous improvement of quality at every stage of road construction. The use of good materials and modern equipment alone does not guarantee high quality. Quality must be managed as a system; it needs to be planned, monitored, measured and adjusted based on the results.

This system was developed through many years of experience in road construction and is known as the **Comprehensive Quality Management System for Construction Works (CQMSCW)**. Its main goal is to ensure that road construction processes are carried out in a coordinated manner and accordance to regulatory requirements, so that the finished road is reliable, durable and safe to operate.

The system includes not only technical but also organizational, social and legal components. The CQMSCW encompasses the ***human factor*** (professionalism and responsibility of workers), ***management*** (control mechanisms and reporting systems), and the ***technological aspect*** (materials used, construction methods, measurement and testing techniques).

The main components of the CQMSCW include:

▪ ***Quality inspection guidelines.*** This document defines at which stage, by whom and by what methods quality checks must be carried out during the road construction process. Essentially, it answers the questions: “When, how and by whom should quality be verified?”

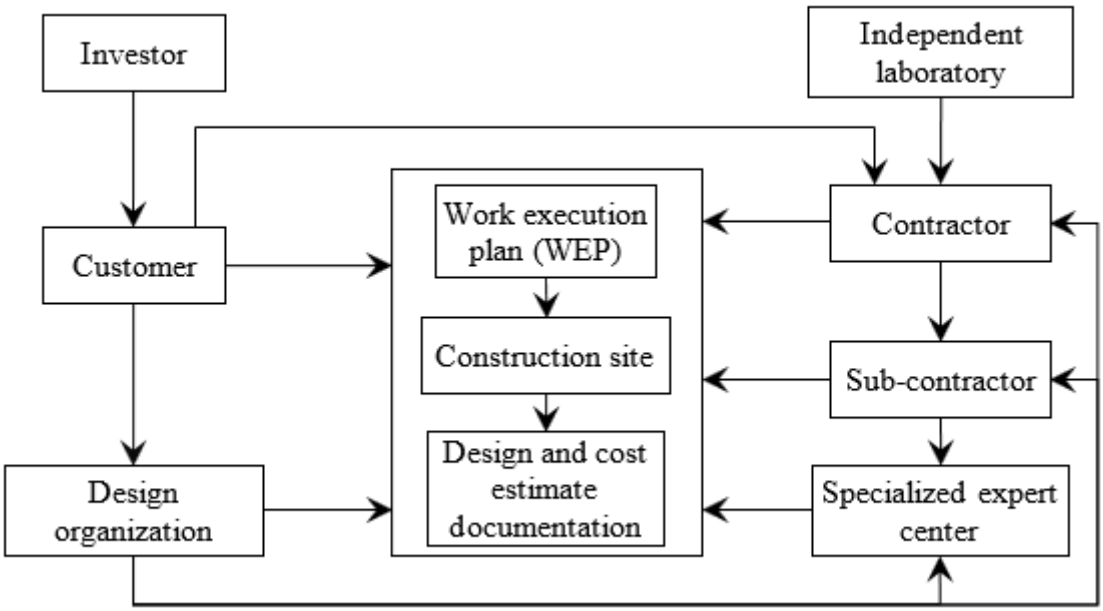
▪ ***Regulations for independent quality control.*** The purpose of these regulations is to ensure that control is not limited to internal inspections conducted by the contractor. Objective evaluation must be carried out by independent laboratories, state control authorities or accredited experts. This approach guarantees transparency and helps prevent possible errors or falsification.

▪ ***Procedures for administrative and financial sanctions for quality violations.*** If norms and standards are violated during construction, responsible individuals and organizations are subject to fines and other administrative measures. This increases accountability and helps prevent negligence regarding quality.

For the CQMSCW system to function effectively, the contractor must rely primarily on **design and estimate documentation** and the **work execution plan (WEP)**. These documents specify in detail how construction will be carried out, what technologies and materials will be used, and what parameters must be achieved.

The main goal of the WEP is to achieve the required quality level - to ensure that the constructed road fully complies with technical specifications stated in the project, is put into operation within the set deadlines and is built with maximum efficiency and minimal cost.

This systematic approach allows for monitoring at every stage of construction, timely detection and correction of errors and the accumulation of valuable experience for future projects. The CQMSCW defines not only **how a road is built** but also **how the construction process is managed**. When the system functions properly, we get safer, more sustainable and longer-lasting roads - a reliable infrastructure foundation for comfortable and safe transportation.



Structural diagram of interaction between participants in the investment process in managing the quality of road construction works

CONCLUSION

The main idea is that to ensure the quality and durability of highways, every stage of the work - from the earliest preparation to road operation - must be carefully planned, carried out under professional supervision and strictly comply with regulatory requirements. This is not only a technical issue but also an organizational, economic and social responsibility.

Road construction is a complex process. The final quality of a road directly depends on many factors including: the decisions made during the design stage, the quality of materials used, the correct choice of technologies, the training of the workforce, as well as climatic and geological conditions. For instance, if the strength of the road structure, the drainage system, or the thickness of the asphalt layers are miscalculated during the design phase, even the most advanced machinery will not ensure the desired result.

Therefore, the involvement of qualified specialists at every stage of road construction plays a decisive role. They not only monitor the progress of the work but also respond promptly to emerging technical problems by offering optimal solutions. Quality does not occur by chance - it is built on knowledge, experience and responsibility.

At the same time, ensuring quality is not only the task of contractors and engineers. The client, supervisory authorities and the state all play crucial roles. The client must establish an effective quality control system, while government agencies ensure compliance with standards. This creates transparency and guarantees the rational use of resources.

When these principles are followed, the result is not just a road but a strategic infrastructure element that supports the country's socio-economic development. High-quality roads facilitate the transport of goods and passengers, strengthen interregional connections, accelerate the turnover of agricultural and industrial products and promote tourism development.

Ensuring quality in road construction is not merely a technical task but a strategic step with economic, social and environmental significance, directed toward the future. A road is not just an asphalt strip; it is one of the arteries of a nation's development. Therefore, every meter of it must be built on a scientific foundation, with technical precision and a sense of responsibility.

Through such an approach, modern, safe and long-lasting roads will be created - forming a sustainable and comfortable transport infrastructure for future generations.

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