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STAGES OF ESTABLISHING A QUALITY MANAGEMENT SYSTEM IN THE CONSTRUCTION MATERIALS INDUSTRY AND MANAGEMENT MECHANISMS

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Abstract:

This article comprehensively examines the theoretical foundations of establishing a quality management system in the construction materials industry, the stages of its implementation, and the mechanisms for its management. During the study, they analyze the influence the quality management system exerts on efficiency in production, product quality, and the competitiveness of the enterprises. The results of the analysis show that the gradual introduction of a quality managing system in accordance with the requirements of the ISO 9001 standard helps to ensure stability of product quality, decrease production costs, while increasing customer satisfaction. In addition, the main mechanisms of quality management system governance— including process-based management, a risk-oriented approach, internal audits, corrective and preventive actions, and continuous improvement methods—are scientifically substantiated.

Keywords: construction materials industry, quality management system, ISO 9001 standard, product quality, production processes, quality control, internal audit, risk-based management, defective products, economic efficiency, competitiveness, continuous improvement.

1. Introduction

The construction materials sector is among the key strategic industries of the economic benefits system and is an integral part of the base of production forces necessary for any country, the development of the productive infrastructure, as well as the satisfaction of morbid needs of the population. Vital to the smooth functioning of this sector are the sustainable operation of construction, the rate of new residential and social facility construction with the development of industrial and transport infrastructure. Hence, the production of construction materials has a critical role in terms of economics, social, and technical issues, related to product quality.

International experience highlights that construction structures quality is directly dependent on the selected materials. Inadequate construction materials do not meet the quality standards necessary for the service life of the structures and increase the cost of maintaining and repairing the structures while sometimes exposing human life and health at risk. Hence, the increasing demands for the quality of construction materials on a yearly basis, requires the manufacturing enterprises to have a systematic and organized approach of assurance of quality.

The competition on the construction materials market of recent years, the complete statu quo of the market economy principles as well as the consent choices of consumers have posed new tasks to their producers. The range of subtasks related to operational efficiency has now become a new normal for enterprises — beyond just growing production volumes, enterprises are also expected to ensure sustained high-quality indicators, compliance with international standards, and optimize related production processes. This, in turn, limits the opportunity for quality assurance to random sampling, or inspection and control.

Both field experience and scientific studies show that what matters in determining product quality is not exclusively whether good methods and tools are employed, but rather the organization of the means of production, the stability and consistency of management decisions, the technological discipline, and the competence of professionals. Quality then has to be controlled, not just at the final inspection stage, but from the selection of raw material, to dispatch of finished products to the customer. It wont be possible to tackle this task without putting in place a quality management system.

It will combine the planning, organizing, controlling and analysis of the enterprise activity into a single management process, which differentiates it to any quality management system. It also helps to minimize production costs, lower the defect rate, and improve customer satisfaction while ensuring product quality stability. Particularly in the building materials industry, the complexities of technological processes, variability of raw materials quality, and effects of external environmental factors necessitate a well-designed quality management system and effective its control process.

Therefore, clearly defining the stages of establishing a quality management system in the construction materials industry, scientifically substantiating their content, and developing effective mechanisms for managing this system constitute a relevant scientific and practical task. This article focuses precisely on these issues, analyzing the main stages of quality management system implementation and presenting practical conclusions on their effective management.

In the contemporary context of the global economy, the construction materials industry belongs to the group of strategic sectors, which have a decisive influence on the socio-economic development of states. The stable operation of the construction sector itself ones also directly tied to the development of this area, the normal provision of the population with high-quality housing, as well as, modernization procedures of production and social infrastructure. From this point of view, quality in the production of construction materials is an issue of special importance, not only due to the economic efficiency but also due to social safety and the sustainable development.

The recent surge in construction volumes, including the opening of new facilities in urban and rural areas, as well as extensive reconstruction and major renovation, has exacerbated demand for construction materials. Nevertheless, such demand is not just the

level of raised production volumes; it also intensifies the weight of product quality parameters. Quality features of modern construction materials are based on parameters such as strength, reliability, environmental safety, energy efficiency and a long service life.

When the quality of construction materials is low, serious problems may arise during the operation of construction structures. In particular, rapid deterioration of structures, an increase in additional repair works, inefficient use of resources, and in some cases a higher likelihood of аварий situations may occur. This can lead not only to economic losses but also to conditions that threaten human life and health. Therefore, the issue of construction material quality is being regarded as one of the priority directions at the level of state policy as well.

However, fewer of them found the answer to remain afloat in the concept of market economy and the increased competition, which brings the construction materials manufacturing enterprise towards a radical rethink of their business model and business strategy. Consumers consider not just price factors, but also quality, reliability, and conformity of products when choosing these, and there are enough statistics and data about it. Hence, the quality is now becoming the leading factor for competitiveness of enterprises on the market. Under these circumstances, there emerges a need to manage quality in a systematic way by designing an integrated system for its planning and control.

Under market economy conditions, the intensification of competition is forcing construction materials manufacturing enterprises to fundamentally reconsider their operations. When choosing products, consumers pay attention not only to price factors but also to quality, reliability, and compliance with standards. As a result, quality is becoming one of the key factors determining enterprises' competitiveness in the market. In such conditions, the need arises to manage quality systematically by establishing an integrated mechanism for its planning and control.

In practical analyses, the general approach to quality in numerous cases of the construction materials, industry is restricted to the final product inspection Instead of getting rid of defects per se, this is a reactive approach with an aim to mitigate the effects of defects. While, the QMS allows to prevent defects, you can continuously keep improving processes, and you can utilize the resources in most efficient manner. It can not only improve the economical efficiency of enterprise work, but also stabilize the quality of products.

Further, digital transformation and the deployment of automation and AI-based production and control systems brings both objectives and requirements for quality management. But in order for such innovative solutions to be realized in practice, the phases of the formation of a quality management system should be developed clearly, scientifically justified and ensured by real tools.

Literature Review on the Topic. Although the theory of quality management and practice in manufacturing industries has been extensively reported in the academic literature, research focusing on the procedures of implementing a system considering the technological, raw-material and standardisation characteristics of the construction materials sector and on the mechanisms for its management has been sporadic. Others are broadly conceptual (principles) while others are narrowly sector-specific (cement, concrete, construction site).

The thoughts of system thinking and continuous improvement from Deming had a strong impact on the formation of modern methodological foundations of quality

management; Deming considered quality not as some separate control function but rather as a responsibility that comes from higher management, advocating for stabilized processes, accountability of top management (Desai, 2013). One simple example is the application of Deming's PDCA logic to the production of construction materials (e.g., clinker burning, grinding, and maintaining stable granulometric composition) for the production of statistical stability and reduced variability. However, a critical aspect should be noted: the Deming approach is fundamentally based on organizational culture and managerial commitment. In institutional environments where standardization and market regulation are weak or insufficiently enforced, PDCA cycles may degenerate into mere "documentary formalities" rather than functioning as effective improvement tools [1].

Juran's concept of the "quality trilogy" (planning–control–improvement) makes it possible to view quality in the construction materials industry through a "life-cycle" perspective—from raw material selection and incoming inspection to technological discipline, laboratory testing, and customer complaints. The strength of Juran's approach lies in substantiating quality as an economic category, particularly through the analysis of quality costs and the cost of defects [2]. However, a critical limitation is that in some enterprises it is difficult to fully implement quality cost accounting: for example, hidden defects, reprocessing activities, and the real costs of claims and complaints may not be adequately reflected in official reports.

In his work *Quality Is Free*, Crosby advances the ideas of "zero defects" and "doing it right the first time." In the construction materials industry, this approach is particularly relevant, as even minor deviations within a product batch (for example, cement strength or setting time, or water absorption in bricks) can affect the quality of an entire construction project [3]. At the same time, a critical perspective should be noted: the "zero defects" philosophy, if not translated into realistic key performance indicators (KPIs) in processes characterized by high technological variability (such as fluctuating raw material composition or difficulties in ensuring stable fuel quality), may lead employees to focus on "working for indicators" rather than achieving genuine quality improvements.

Feigenbaum's concept of *Total Quality Control* substantiates the integration of quality across enterprise departments, forming a unified quality chain that includes laboratory services, procurement, production, logistics, sales, and after-sales service. This approach is particularly important for the construction materials industry, as quality defects often originate not only from technological workshops but also from supply (raw materials), storage, transportation, or certification processes. A critical aspect, however, is that such integration requires strong organizational capacity. In enterprises with limited resources, if full integration is not implemented gradually and prioritized on a risk-based basis, the quality management system may be perceived as an "overly bureaucratic" burden rather than an effective management tool [4].

Contemporary studies in the construction and materials sector demonstrate a tendency to integrate quality management not only with product parameters but also with safety, environmental standards, and digital monitoring systems. For example, empirical analysis of the Iranian cement industry shows that the integration of ISO 9001, ISO 14001, and OHSAS 18001 has had a positive impact on safety indicators, illustrating the practical applicability of the "Integrated Management System" (IMS) approach in construction materials. However, such studies are not always consistent: in many cases, external factors

influencing outcomes—such as investment levels, equipment modernization, and market conditions—are not sufficiently isolated or controlled [5].

In addition, there are studies that provide an in-depth analysis of the "material factor" as one of the drivers of reduced construction quality. Variability in material quality, certification practices, conditions of application, and insufficient control can all adversely affect construction quality. These findings highlight, for construction materials manufacturers, the important distinction between "demonstrating conformity" (testing, inspection, certification) and "ensuring conformity" (process capability, preventive actions) [6].

Finally, a critical line of research emphasizes that the implementation of ISO 9001 does not always produce automatic positive outcomes. Some studies identify the reasons for low effectiveness even in ISO-certified organizations, including formalistic implementation, weak involvement of top management, internal audits conducted merely as a "check-the-box" exercise, and the incorrect selection of process KPIs. These findings provide strong scientific support for the argument that, in organizing the stages of a quality management system within the construction materials industry, the primary objective should not be obtaining certification itself, but rather establishing a genuinely functioning and effective system [7].

The ISO 9001:2015 standard requires quality management to be built on the principles of a process-based approach, risk-based thinking, and continuous improvement. For the construction materials industry, these requirements are well aligned with managing the "raw materials–production–testing–storage–delivery" chain as a set of interconnected processes. However, the standard itself defines not "which technology" to use, but rather "how to manage." Therefore, if ISO 9001 is not harmonized with industry-specific technological regulations, national standards, and laboratory methodologies, it may fail to deliver the expected effect within an enterprise [8].

Under the conditions of Uzbekistan, the topic of quality management has in recent years been addressed in close connection with the standardization and certification system, the modernization of sectoral enterprises, innovation, and the adoption of "green" technologies [9]. In the studies of O.Sh. Mustafayev, the advantages of ISO 9001:2015 are emphasized, particularly its potential to reduce defects and streamline management through implementation at enterprises. These works provide methodological guidance for local companies; however, a critical point remains that in many articles empirical evidence—such as comparative statistics, defect rates, and process capability indices—is not presented in sufficient depth, and the conclusions often remain at a general descriptive level [10].

In several local studies focusing on the construction materials industry (particularly cement production), international experience models such as TQM, Lean, Six Sigma, and Kaizen have been compared with the ISO 9001 approach, and their advantages and limitations have been identified. The value of research in this direction lies in demonstrating the need for an industry-specific "hybrid model." However, a critical point is that, in order to avoid remaining detached from practice, merely listing models is insufficient; it is necessary to clearly specify at which stages of construction materials production (for example, raw material preparation, burning, grinding, packaging, and logistics) each model should be applied, along with the corresponding KPIs and implementation tools.

In the context of innovative management and innovative competitiveness, E.

Khaydarova raises a question of managing the innovative potential of enterprises of the construction materials sphere. Thus, the aspect related to quality management in this case is that the introduction of innovations (new additives, new compositions and energy-saving technologies) is always associated with an increase in risk, and therefore, the risk-based management principles of a quality management system should overlap with innovative activity. A critical point, however, is that studies on innovation management often fail to fully explain the mechanisms for "linking" innovation with quality indicators (standard requirements, certification, and laboratory methods). As a result, innovation and quality may remain as two separate and weakly connected directions [11].

Another group of local normative and applied studies focuses on the interrelationship between certification, standardization, and quality management systems. This line of research is significant in that it explains how the "conformity infrastructure" of the construction materials market—testing laboratories, certification bodies, and technical regulations—influences quality management. However, a critical aspect is that when standardization and certification are interpreted predominantly within a "control" paradigm, there is a risk that the preventive nature of quality management systems, aimed at eliminating deficiencies in advance, may be relegated to a secondary role [12].

In addition, recent studies in Uzbekistan devoted to quality control systems in design and construction processes analyze institutional and organizational mechanisms. These studies are also important for construction materials manufacturers, as requirements related to "on-site quality" and acceptance procedures demonstrate how effectively the quality management system operates in practice at the manufacturing level (through complaints, laboratory test reports, and technical supervision conclusions) [13].

The previous sections of the review provide a foundation for the following scientific conclusion: in the sector of construction materials, the implementation of QMS is not a separate body of knowledge or a set of rules that can be adequately expressed by the phrase "meeting standard requirements"; it is an integrated management model that, if properly implemented, serves stability of technological processes, raw material variability and preventive approach to conformity, all at the same time. Whereas classical international scholars deliver the ideational basis (PDCA, the quality trilogy, zero defects, integration), sector studies indicate implementation gaps such as cement production and construction practice. Research at local contexts have mainly focused on the standardisation and practices of implementation; yet, further strengthening the empirical basis and connecting cause–effect between "which mechanism, to achieve which outcome"—is still required. The gap highlights the relevance of the current article, which aims to propose the stages of implementation of the quality management system and management mechanisms in a structure appropriate for specific industry characteristics and associated with the measurable outcomes.

2. Materials and Methods

Using methods of systems analysis, historical and logical analysis, induction and deduction, analysis and synthesis, comparative and selective research, monographic analysis, and grouping, the study provides the analysis of stages of quality management system instantiation in construction materials industry and mechanisms for their management, as well.

3. Results and Discussion

In substantiating the establishment of a quality management system (QMS) and its management mechanisms in the construction materials industry, the "dynamics of production volumes within the sector" is considered a key indicator. This is because growth in output, as a rule, increases process variability (raw material composition, energy supply, technological regimes) and quality-related risks (defect rates, customer complaints, deviations from standards). From this perspective, practical conclusions for QMS development are drawn based on cement production indicators for the period 2020–2024, as cement represents the largest segment within the construction materials industry.

Table 1. Production volumes and quality indicators of construction materials in Uzbekistan, 2020–2024 [14]

Year	Production volume (trillion UZS)	Share of enterprises implementing ISO 9001 (%)	Share of defective products (%)
2020	18,5	32	7,8
2021	21,3	38	6,5
2022	25,7	47	5,1
2023	29,9	56	3,9
2024	34,6	63	2,7

The table given above indicates that during the period from 2020 to 2024, the production volume of construction materials nearly doubled. Alongside this growth, the share of enterprises that implemented a quality management system in accordance with the ISO 9001 standard also increased steadily (Table 1).

A noteworthy point is that, with the implementation of quality management systems, the share of defective products decreased proportionally. While this indicator stood at 7.8 percent in 2020, it declined to 2.7 percent by 2024. This trend demonstrates the practical effectiveness of quality management mechanisms.

Table 2. Level of implementation of quality management system elements in Uzbekistan, 2020–2024 [15]

Indicators	2020	2021	2022	2023	2024
Incoming raw material inspection (%)	45	52	61	70	78
Coverage of laboratory testing (%)	48	55	64	73	81
Enterprises conducting internal audits (%)	30	36	45	54	62
Employee training and qualification improvement (%)	28	34	43	52	60

The table shows that positive growth has been observed across all key elements of the

quality management system (Table 2). In particular, after 2022, the coverage of incoming raw material inspection and laboratory testing expanded significantly.

The growth in internal audit and employee training indicators signifies a shift toward managing quality not only through technical measures but also through organizational and human factors. This transition has ensured the stable functioning of the quality management system.

Table 3. Economic efficiency of the quality management system [15]

Year	Losses due to defects (billion UZS)	Share of corrective costs (%)	Customer complaints (Qty)
2020	420	6,2	1350
2021	390	5,6	1180
2022	310	4,8	920
2023	240	3,9	710
2024	180	3,1	540

The data indicate that as the quality management system developed, losses caused by defects decreased sharply (Table 3). Compared to 2020, economic losses in 2024 were reduced by approximately 2.3 times.

In addition, the decline in the number of customer complaints indicates an increase in market trust toward manufacturers. This situation proves that quality management mechanisms have a positive impact not only on production processes but also on marketing performance and overall competitiveness.

Based on the results of the conducted research, the analysis of statistical data for the period 2020–2024 demonstrates that the step-by-step implementation of a quality management system in the construction materials industry has ensured the stability of product quality, reduced production costs, and increased the economic efficiency of enterprises.

These results scientifically substantiate the necessity of widely implementing quality management systems across all enterprises in the sector (Figure 1).

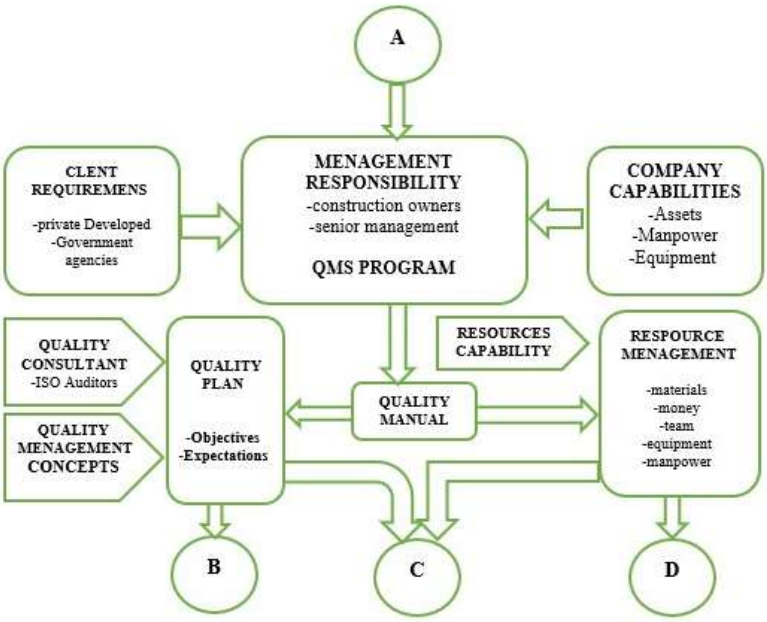

Figure 1. General scheme of the quality management system in the construction materials industry

Where:

External environment: market demand; regulatory and legal requirements; customer needs.

Enterprise management: quality policy; quality objectives; strategic decisions.

Core processes: raw material acceptance; technological production; inspection of finished products.

Supporting processes: personnel training; laboratory control; documentation management.

Outcome: high-quality products; customer satisfaction; market competitiveness.

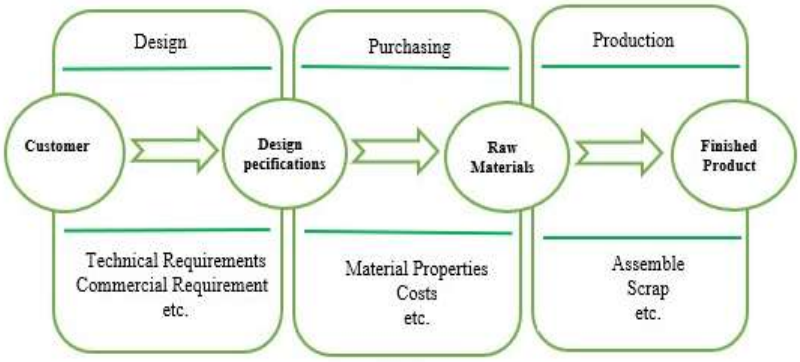

Figure 2. Process-based approach in accordance with the ISO 9001 standard

According to the information presented in the figure, the following elements are identified (Figure 2): Inputs: customer requirements; raw materials and resources.

Planning (Plan): setting quality objectives; risk identification.

Implementation (Do): production processes; compliance with technological regulations. Checking (Check): laboratory testing; internal audits; analysis of quality indicators. Improvement (Act): corrective actions; preventive measures; continuous improvement.

Scientific study of the processes involved in forming organizational management systems in enterprises began more than 200 years ago. In large industrial enterprises of the late nineteenth and early twentieth centuries, organizing production processes was virtually impossible without a structured organizational management system. According to the views of A. Fayol and F. Taylor, forming an organizational management system in enterprises on the basis of defined principles makes it possible to structure production sequences and to apply clear approaches to monitoring the implementation of managerial decisions [16], [17]. A McKinsey study indicates that the proper establishment of an organizational management system in enterprises creates up to 80% favorable conditions for achieving the intended results [18]. Furthermore, according to European Union scholars in 2020, an effective organizational management system enables enterprises to achieve their predetermined objectives in approximately 90% of cases (Figure 3) [19]

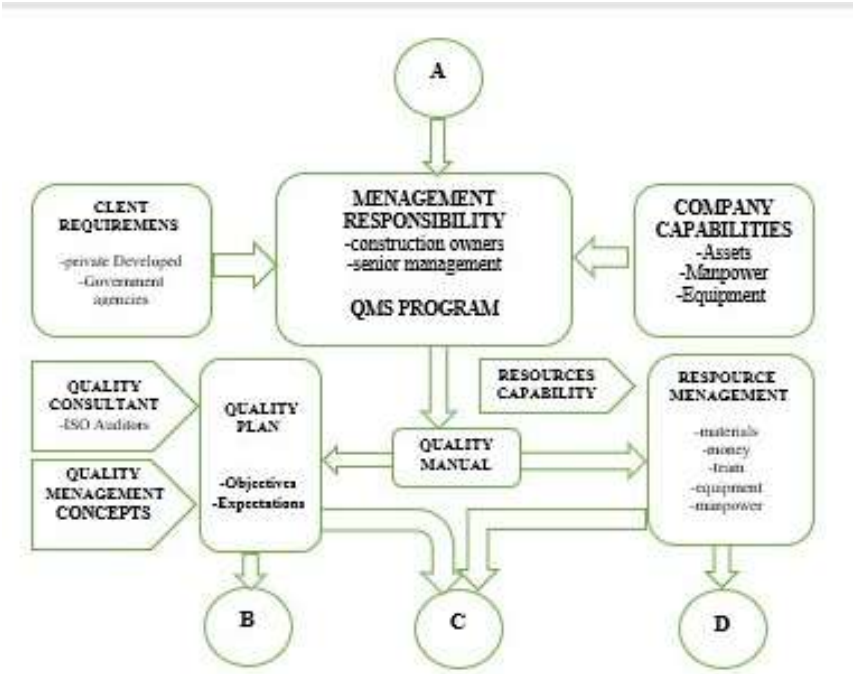

Figure 3. Quality control mechanism in construction materials production

According to the information presented in the figure, the following elements are identified:

Incoming control: raw material quality; verification of certificates.

In-process control: technological parameters; equipment condition.

Final inspection: assessment of finished product quality; compliance with standards.

Feedback: defect analysis; elimination of root causes.

4. Conclusion.

The implementation of a quality management system and its effective management in the construction materials industry clearly demonstrate their strategic importance. Under conditions of rapid industrial development, increasing investment volumes, and intensified

competition in both domestic and international markets, ensuring stable product quality is becoming a key priority in enterprise operations.

The analysis results indicate that in construction materials manufacturing enterprises where a quality management system has been implemented in a systematic and step-by-step manner, production process transparency has increased, the share of defective products has decreased significantly, and economic efficiency has been ensured. In particular, the process-based management model in accordance with the requirements of the ISO 9001 standard has enabled quality control at all stages of production.

At the same time, the research findings demonstrate that a quality management system is not merely a set of control and inspection procedures, but an important instrument of strategic enterprise management. By clearly defining quality policy and objectives, implementing a risk-based approach, and carrying out corrective and preventive actions, enterprises have achieved greater operational stability. This further emphasizes the significance of a preventive approach to quality management.

The study reveals that the effectiveness of a quality management system largely depends on the human factor. Employees' qualifications, their attitude toward quality, corporate culture, and the personal responsibility of management are among the key factors determining quality outcomes. Continuous training, professional development, and active employee involvement in internal audit processes ensure the continuity of quality assurance.

The analysis for the period 2020–2024 also shows that the introduction of digitalization and innovative technologies is elevating quality management systems to a new stage of development. The use of electronic monitoring, automated laboratory control, and data analysis software enables real-time tracking of quality indicators. This is particularly important for ensuring compliance with international standards in the production of construction materials oriented toward export markets.

Overall, the comprehensive, consistent, and scientifically grounded establishment of quality management systems in the construction materials industry is important not only for individual enterprises but also for the development of the entire sector. The widespread implementation of quality management systems contributes to the efficient use of resources, reduction of production costs, increased customer trust, and the sustainable growth of the national economy.

In the future, it is advisable to further improve quality management systems in the sector, expand the adoption of international best practices in the activities of local manufacturers, develop digital management mechanisms, and support quality management at the level of state policy. This will serve as a solid foundation for ensuring the long-term competitiveness of the construction materials industry

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