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Suppliers as a Factor of Improvement Economic Efficiency of the Enterprise

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Abstract: The application of statistical methods of quality control and management of products in relation to concrete production is considered. The experimental part of the research was carried out using standard methods and laboratory equipment. The results of the assessment of the state of the technological process (stability and reproducibility) of the production of concrete products are presented. It is shown that the production of concrete based on sand from the Russeevsky quarry is characterized by low reproducibility, which contributes to the level of product defects amounting to 7.84%.The use of sand from the Surskoye deposit with the same grade of concrete helps to reduce the level of concrete defects to 0.21%.It is proposed to supplement the supplier evaluation system with a criterion that evaluates the influence of raw materials on the stability and reproducibility of the final product.

1 INTRODUCTION

Increasing the economic efficiency of enterprises is one of the goals of the implementation of the National Project of the Russian Federation "Efficient and competitive economy”. Economic efficiency is determined by the ratio of the economic effect or result of an activity and the resources invested in achieving this effect or result. The stated goal is achieved by eliminating or optimizing unproductive operations from technological and related processes that generate resource losses. The construction industry is currently experiencing the influence of negative factors that create preconditions for the need to minimize resource losses: rising costs, shortage of personnel, decrease in demand. At the same time, the procurement function in construction is a tool for managing enterprise resources through proactive work in the internal and external environments at each stage of the procurement cycle: formalization of needs, work with the market, conducting the procurement procedure and concluding the contract, management of cooperation and contractual obligations. If the stage of formalization of the needs of a construction company is characterized by the study of product requirements, based on both regulatory documentation, and on the expectations of interested parties, takes place in the internal environment, while work with the market is focused on the external. The purpose of work in the external environment is to form a list of suppliers suitable for participation in the procurement procedure, based on the screening out of potential supply sources that do not meet the requirements. The work at this stage of the procurement cycle is divided into two parts: In the first part, suppliers are selected that meet the minimum requirements for resources, processes, and experience; in the second part, suppliers’ proposals are evaluated based on quality and cost criteria. Using the blocking criteria of the second part, the buyer evaluates the suppliers' proposals, having passed the selection, which, in addition to the specified resource requirements, process and experience, should contain characteristics that reflect the state of the supplier's production process in the medium term, and not to indicate a cut at a particular observation point. This is due to the buyer's requirement not only to receive a product with the expected characteristics, but also

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maintaining the characteristics unchanged throughout the entire life cycle of the contract.

Let's consider the introduction of a criterion by the buyer "constancy" or "sequence" management of the product production process in the selection of suppliers during work with the market of the purchasing cycle, which will allow:

1. Select supply sources based on an assessment of the supplier's production process status, ensuring the expected level of product characteristics throughout the entire life cycle of the contract;
2. Exclude suppliers whose processes do not guarantee the receipt of products with the stated requirements, thereby rationalizing the number of proposals requiring evaluation;
3. Avoid wasting resources when repeating the procurement cycle due to the urgent selection of an alternative source of supply;
4. Create a reserve list of alternative supply sources, the processes of which, when studied, demonstrated the potential for bringing the characteristics closer to the declared level;
5. Do not return defective products, ensuring continuity of the operational process and saving resources;
6. Reduce the time required to complete the procurement cycle, increasing the efficiency of the procurement function and the economic efficiency of the enterprise as a whole.

The stability and reproducibility of the product manufacturing process give the buyer an idea of the level of "constancy" or "sequence" , where is the statistical office, determined by the measurement and accumulation of data on key indicators of product quality and the production process, allows for a comprehensive assessment of the current state and the past period. The methods and tools of statistical management include: Pareto analysis, process histograms, Shewhart control charts, scatter diagrams.

Let us consider the application of Shewhart control charts in the selection of sand in the production of concrete.

2 MATERIALS AND RESEARCH METHODS

A construction company is considered as a buyer, the construction sites of which are located in the Penza region and directly in the city of Penza. As suppliers of sand for the production of concrete wall blocks, which the buyer acquires, The following enterprises were taken: Russeevsky quarry and Sursky quarry (Penza city). To eliminate the influence of equipment wear, statistical data were taken for the period of time for the qualification of personnel, slightly different in duration, assessing the medium-term perspective of the state of the process.

The stability of the technological process of block production was assessed using Shewhart control charts, process reproducibility - according to the reproducibility index C_p and C_{pk}.

To construct control charts and calculate the reproducibility indices Cp and C pk, statistical data on the release strength of concrete blocks for basement walls made from sand from each of the suppliers at the company OOO Stroitelnye Materialy, Penza, were used (Fig. 1).

Concrete grade 100, release strength is 70% of the design strength. Reproducibility indices were calculated using the formulas:

$$C_p = \frac{ULR - LLR}{6\sigma} \quad (1)$$

or

$$C_{pk} = \min\{\frac{ULR - \bar{x}}{3\sigma}; \frac{\bar{x} - LLR}{3\sigma} \quad (2)$$

where ULR, LLR is upper and lower tolerances for the concrete strength index (respectively 10.5 MPa and 7.0 MPa).

At C_{pk} >1.33 the process is reproducible, at C_{pk} =1 the process is reproducible, but requires careful attention, at C_{pk} <1 the process is not reproducible.

All data on concrete strength values were divided into 6 samples, for each of them the arithmetic mean and the standard deviation were calculated.

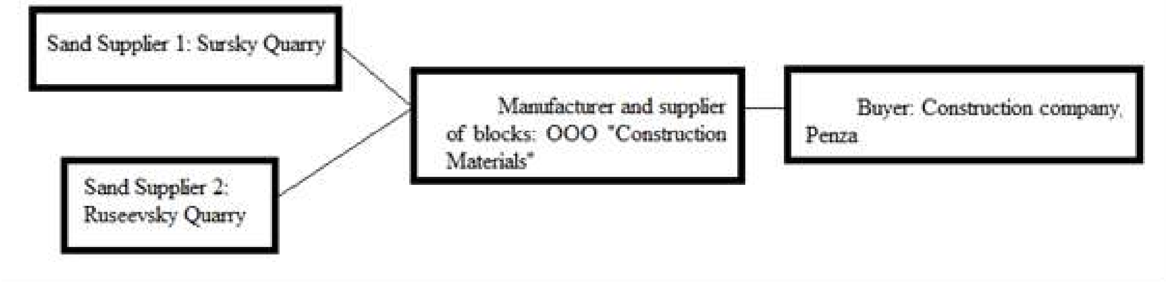


Figure 1: Supply chain.

3 RESEARCH RESULTS

The calculation results are shown in Fig. 2,3 and Table 1-3.

Sursky quarry. The strength values are, MPa: 9.2, 9.4, 7.7, 8.3, 9.4, 8.4, 8.0, 8.8, 9.0, 8.8, 8.0, 8.4, 9.1, 9.7, 10.0, 9.0, 9.2, 9.0, 9.2; 9.4; 9.6; 8.6; 8.3; 8.6; 8.8; 7.8; 9.0, 9.6, 8.0, 8.7, 8.8, 9.2, 9.7, 9.4, 9.6, 9.0, 8.8, 8.3, 8.4, 8.8, 9.2; 9.4; 10.0; 10.0; 9.4; 9.4; 10.0; 9.4; 9.0; 9.2; 9.6; 8.6; 9.2; 8.8; 8.6; 8.5; 9.0; 9.3; 9.8; 8.6.

Table 1: Statistical characteristics of the sand quality indicators of the Sursky quarry.

Sample number, n	Sample size, n	Release strength index, x_i, MPa	Mean arithmetic value, MPa	$(x_i - \bar{x})^2$	Standard deviation value, MPa
1	10	9.2	8.7	2.5	0.555
		9.4		4.9	
		7.7		10.0	
		8.3		1.6	
		9.4		4.9	
		8.4		0.9	
		8.0		4.9	
		8.8		0.1	
		9.0		9	
		8.8		0.1	
2	10	8.0	9.1	12.1	0.548
		8.4		4.9	
		9.1		0	
		9.7		3.6	
		10.0		8.1	
		9.0		0.1	
		9.2		0.1	
		9.0		0.1	
		9.2		0.1	
		9.4		0.9	
3	10	9.6	8.7	8.1	0.566
		8.6		0.1	
		8.3		1.6	
		8.6		0.1	
		8.8		0.1	
		7.8		8.1	
		9.0		0.9	

		9.6 8.0 8.7		8.1 4.9 0	
4	10	8.8 9.2 9.7 9.4 9.6 9.0 8.8 8.3 8.4 8.8	9.0	0.4 0.4 4.9 1.6 3.6 0 0.4 4.9 3.6 0.4	0.449
5	10	9.2 9.4 10.0 10.0 9.4 9.4 10.0 9.4 9.0 9.2	9.5	0.9 0.1 2.5 2.5 0.1 0.1 2.5 0.1 2.5 0.9	0.349
6	10	9.6 8.6 9.2 8.8 8.6 8.5 9.0 9.3 9.8 8.6	9.0	3.6 1.6 0.4 0.4 1.6 2.5 0 0.9 8.1 1.6	0.455
Σ		54.0			

Central lines: for =9.0 MPa; for s=0.487 MPa
Regulation limits or the $\bar{x}$ -card:

$$LR = \bar{\bar{x}} \mp \frac{3\sigma}{\sqrt{n}} = 9.0 \mp \frac{3 * 0.525}{\sqrt{10}}$$

$$\sigma = \frac{\bar{s}}{c_2}$$

The control limits for the $\bar{s}$ -card are calculated using the formulas

$ULR=B_4 \cdot \bar{s}$ =0.836

$LLR=B_3 \cdot \bar{s}$ =0.137

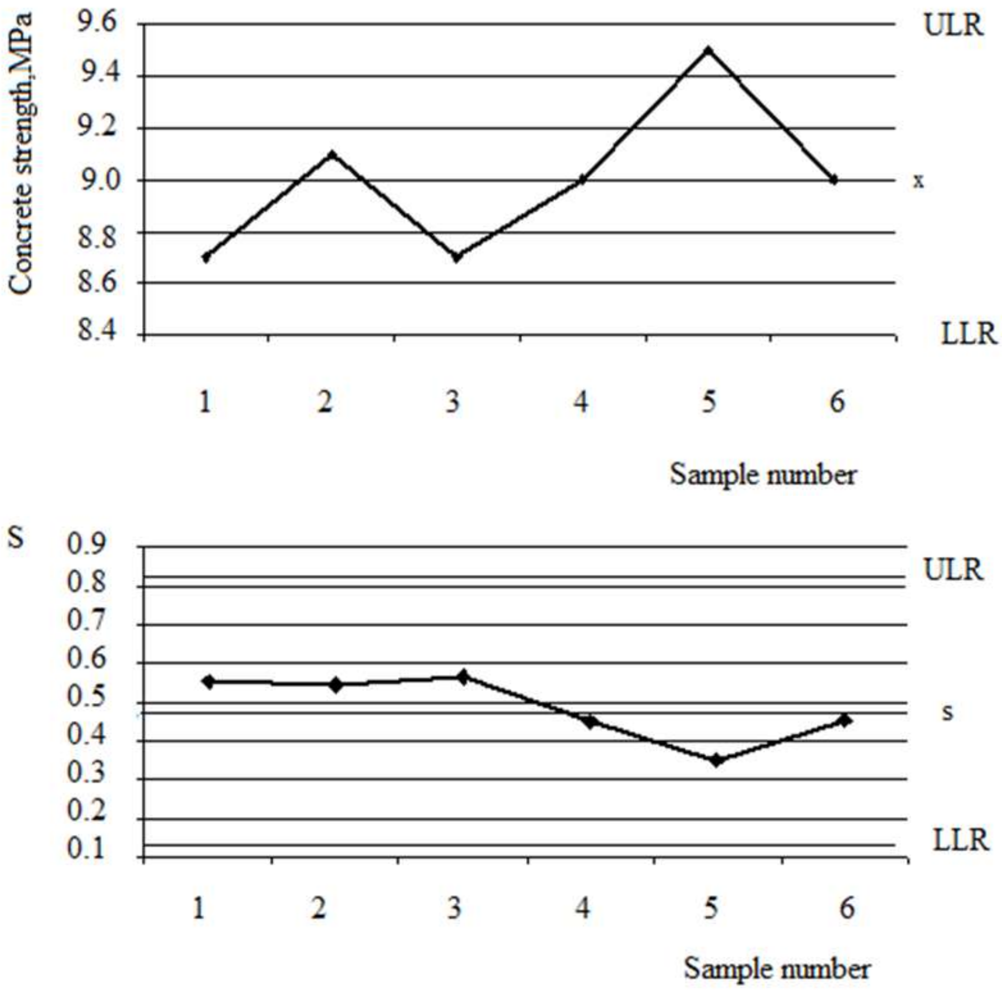


Figure 2: x- $\bar{s}$ -map of the production of concrete based on the sand of the Sursky quarry.

Since the points on the $\bar{x}$ - $\bar{s}$ - -map do not go beyond the control limits, this means the production process is stable. Reproducibility indices are used to objectively assess the quality of the technological process of manufacturing products.

Reproducibility indices were calculated using formula (2).

The calculation results show that the value of Cpk = 1.03, which means that the process is reproducible, but requires careful attention.

Russeevsky quarry. The values of concrete strength are, MPa :10.0, 7.9, 9.2, 8.3, 8.7, 7.5, 7.8, 7.6, 8.3, 8.7, 7.5, 8.8, 7.5, 7.8, 7.5, 9.9, 7.6, 7.2, 8.191,7.0, 8.0, 7.5, 7.8, 7.6, 7.9, 8.0, 8.6, 8.5, 8.1, 8.0, 7.8, 7.9, 8.4, 7.2, 7.3, 7.2, 7.8, 9.0, 8.4, 7.3, 7.2, 7.6, 7.5, 7.3, 9.1, 8.0, 8.7, 9.3, 8.0, 7.6, 7.9, 8.4, 7.5, 9.2, 8.4, 9.0, 7.6, 8.4, 9.0.

Table 2: Statistical characteristics of the sand quality indicators of the Ruseevsky quarry.

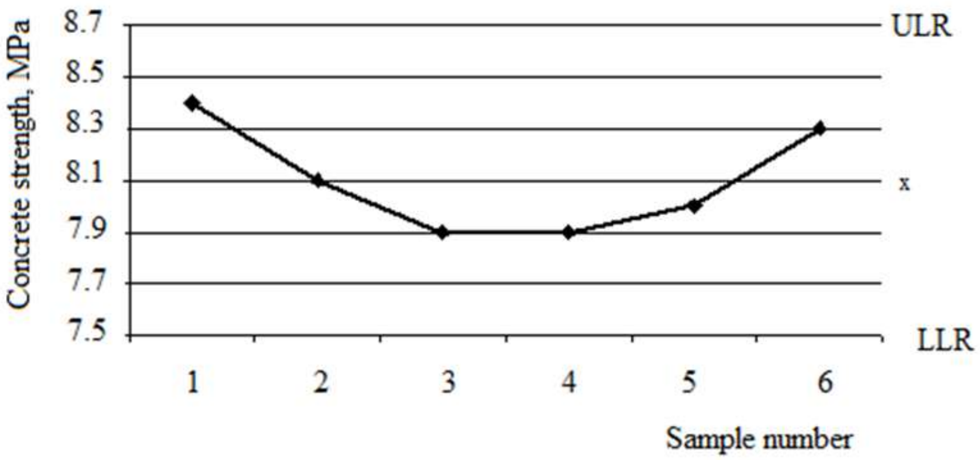
Sample number, n	Sample size, n	Release strength index, x_i, MPa	Arithmetic mean value, MPa	$(x_i - \bar{x})^2$	Standard deviation value, MPa

1	10	10.0 7.9 9.2 8.3 8.7 7.5 7.8 7.6 8.3 8.7	8.4	3.6 2.5 6.4 0.1 0.9 8.1 3.6 6.4 0.1 0.9	0.571
2	10	7.5 8.8 7.5 7.8 7.5 9.9 7.6 7.2 8.1 9.1	8.1	3.6 4.9 3.6 0.9 3.6 3.24 2.5 8.1 0 10.0	0.834
3	10	7.0 8.0 7.5 7.8 7.6 7.9 8.0 8.6 8.5 8.1	7.9	8.1 0.1 1.6 0.1 0.9 0 0.1 4.9 3.6 0.4	0.445
4	10	8.0 7.8 7.9 8.4 7.2 7.3 7.2 7.8 9.0 8.4	7.9	0.1 0.1 0 2.5 4.9 3.6 4.9 0.1 12.1 2.5	0.555
5	10	7.3 7.2 7.6 7.5 7.3 9.1 8.0 8.7 9.3 8.0	8.0	4.9 6.4 1.6 2.5 4.9 12.1 0 4.9 16.9 0	0.736
6	10	7.6 7.9 8.4 7.5	8.3	4.9 1.6 0.1 6.4	0.60

		9.2 8.4 9.0 7.6 8.4 9.0		8.1 0.1 4.9 4.9 0.1 4.9	
Σ		48.6			

The control limits for the x-card are: ULR=8.7 MPa, LLR=7.5 MPa

The control limits for the $\bar{s}$ -card are: ULR=1.07 MPa; LLR=0.176 MPa



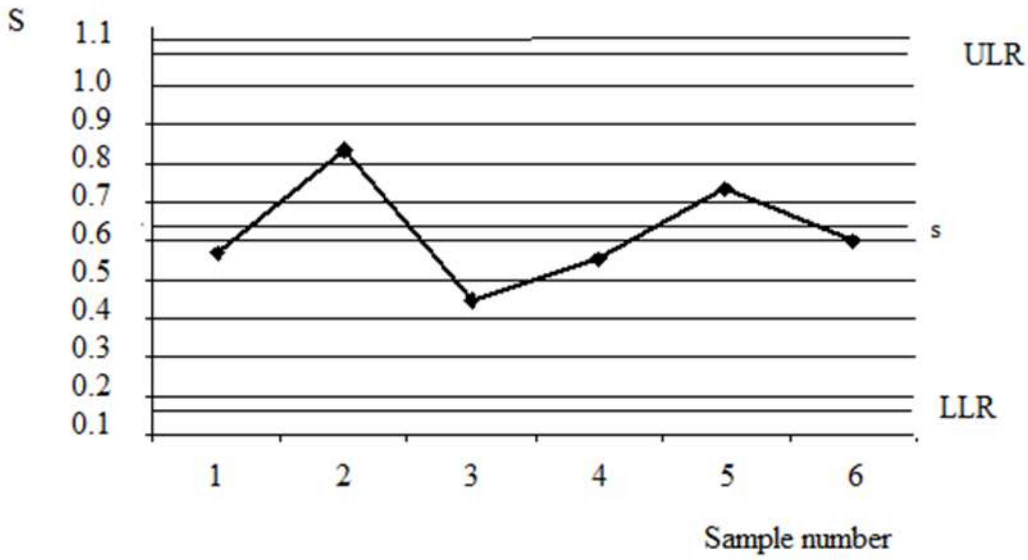


Figure 3: x- $\bar{s}$ -map of concrete based on sand Ruseevsky quarry.

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The reproducibility index is equal to

$$C_{pk} = min\frac{10.5 - 8.1}{3 * 0.624};\frac{8.1 - 7.0}{3 * 0.624} = 0.59$$

The obtained calculation results show that the points on the control charts for Sursky and Russeevsky sand do not go beyond the control limits, the process is stable. But in the case of using Russeevsky sand, the process of producing concrete blocks turned out to be non-reproducible. Table 3 shows the values of the level of defective products depending on the type of sand. When using Russeevsky sand, the level of defective products is 7.84%.

Table 3: The influence of the type of sand supplier on the level of product defects.

Sand supplier	State of the technological process of production of concrete blocks	Reproducibility indices	Defectiveness level,%
Sursky quarry	The production process is stable, reproducible, but requires attention	1.03	0.21
Russeevsky quarry	The production process is stable but not reproducible.	0.59	7.84

4 CONCLUSION

Based on the results of the assessment of the state of the concrete block production process using two options for raw material supply sources, the buyer should, at the stage of working with the market, accept the following option for forming a supply chain as the main one: sand supplier No. 1 Sursky quarry, manufacturer and supplier of concrete blocks OOO Stroitelnye Materialy. In the absence of the criterion of “consistency” or “consistency” in managing the product production process in the first part of working with the market of the procurement cycle, where the source of supply is directly analyzed – its processes, resources, experience, it is not possible to guarantee the receipt of a product with characteristics that meet the stated requirements, within the framework of the fulfillment of contractual obligations. This is confirmed by the obtained values of the level of product defects, which are directly dependent on the state of the technological process, which in the case under study has significant deviations due to the various characteristics of first-level suppliers, raw materials. Consequently, the introduction of the criterion of "consistency" or "consistency" in the selection ensures the selection of those supply sources that, when forming proposals to the buyer at the stage of the procurement procedure, demonstrate compliance with the requirements of regulatory documentation and meet the expectations of stakeholders throughout the life cycle of the product. At the same time, due to the observed shortage of counterparties characterized by a guaranteed level of product quality, it is recommended to further clarify the factors influencing the supply chain in the construction industry: sand supplier No. 2 Ruseyevsky quarry, manufacturer and supplier of concrete blocks OOO "Construction Materials", leading to a decrease in the indicators of the technological process and an increase in the level of product defects.

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