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Professional paper

QUALITY MANAGEMENT OF THE CONSTRUCTION OF SMART CITIES, WITH REFERENCE TO THE CONTROL OF THE MATERIALS THAT ARE INSTALLED

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Abstract

Quality management is an important activity that is aimed at improving performance, which reduces costs, raises employee morale and constantly acts to improve the quality of products. This also affects the competitive position of the company in the market, strengthening the trust of the users themselves. Construction constantly strives to adopt new quality elements in order to gain an advantage over the competition.

The modern development of quality management has resulted in the establishment of full quality management TQM (Total Quality Management).

Keywords: *quality, TQM, reinforcing steel, standards, testing*

Introduction

The aim of the paper is to familiarize civil engineers with the need for quality management, which is a revolutionary step in increasing business efficiency, which is equally important for all phases of construction.

F.G. Steingraber from the company "AT Kearney" gives an explanation of the concept of quality:

"Traditionally, we thought of quality as achieving specifications, meeting requirements, eliminating deviations in the product. We assumed that quality was satisfactory if products were not returned, if we did not receive criticism and if we improved the price-performance ratio for users. Today, quality evaluation it's not just a matter of meeting the user's expectations, but exceeding them."⁴

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Basics of construction quality management

There must be a trained manager in the performance.

It is the most critical factor in the successful introduction of TQM. It must also affect other employees in terms of quality acceptance. After the introduction of TQM, new employees should be constantly instructed in the fundamental principles of TQM.

In order to introduce TQM, there must be certain rules, both for the manager and for his employees.

TQM should be directed towards the company's strategic goals. It must not be monopolized by the owner, but integrated into all areas and activities of the company. During the introduction, it is necessary to plan long-term, in order to be effective, the data should be standardized.

Right from the start, you should have the user's requirements, and then determine the procedure and methods according to them.

The evaluation of the quality of construction and the material used in smart buildings is shown on the example of the evaluation of control steel for reinforcing concrete structures - a material that is basic for every construction, including for smart construction.

Conformity assessment procedure^[2]

The appointed body, i.e. the conformity assessment body, carries out the conformity assessment of steel for concrete reinforcement, at the request of the manufacturer or his representative.

The conformity assessment procedure includes, according to the SRPS EN 10080 standard:

- 1) factory production control;
- 2) initial type examination;
- 3) permanent supervision of factory production control and control testing.

During the production of steel for concrete reinforcement, a permanent system of factory production control is established, which is carried out using the methods established by the SRPS ISO 9001 and SRPS EN 10080 standards.

Taking samples^[2]

Sampling of steel for concrete reinforcement should be performed exclusively by an authorized representative of the appointed body, i.e. an authorized representative of the conformity assessment body, in the presence of the manufacturer's representative or his representative, while a record of sampling is drawn up and certified by representatives of both parties.

The test unit for bars and coils is taken from a lot or part of a lot.

Mandatory steel tests for concrete reinforcement, determined by the SRPS EN 10080 standard, for:

- 1) chemical composition, one analysis per batch;
- 2) tension tests, one test sample per 30 t, with at least three test samples per test unit (produced quantity - batch) and nominal diameter;



3) bending tests and/or retests, mass per length meter and surface configuration, one test sample per test unit (produced quantity - batch) and nominal diameter.

The test unit for welded meshes and lattice supports consists of panels and lattice supports of the same steel class and diameter, produced on the same welding machine with a maximum mass of 50 t. The number of samples per unit for testing as well as the properties to be tested are determined by the SRPS EN 10080 standard.

Certificate of conformity^[2]

Before delivering steel for concrete reinforcement to the market, it is necessary for the manufacturer, his agent, importer or distributor to obtain a certificate of conformity.

If the procedure for assessing the conformity of steel for concrete reinforcement has been carried out and if the results of the sample tests show the conformity of steel for concrete reinforcement with the requirements, the designated body, i.e. the manufacturer, issues a certificate of conformity.

A document of conformity is a certificate of conformity and a declaration of conformity.

The certificate of conformity is issued by a designated body which, in addition to the requirements for designation prescribed, also meets the requirements established by the SRPS ISO/IEC 17065 standard.

The declaration of conformity is drawn up by the manufacturer based on the test report and technical documentation, in accordance with the requirements prescribed by this regulation.

The test report of steel for concrete reinforcement is issued by an accredited conformity assessment body, which meets the requirements set by the SRPS ISO/IEC 17025 standard.

The certificate of conformity should be valid for one year from the date of issue, and a declaration of conformity is issued for each batch.

Designated Conformity Assessment Body^[2]

The conformity assessment body can carry out the conformity assessment of concrete reinforcing steel, if it meets the following conditions:

- 1) they must not be designers, manufacturers, suppliers of steel for concrete reinforcement, nor representatives of any of the interested parties and must not be involved, directly or as representatives, in the design, marketing or production of steel for concrete reinforcement;
- 2) personnel with technical knowledge, as well as sufficient and appropriate experience for performing conformity assessment tasks, as well as appropriate authorization for performing conformity assessment tasks;
- 3) test equipment;
- 4) should have a corresponding general act;
- 5) concluded insurance contract against liability for damage;

The possibility of exchanging technical information between the manufacturer and the conformity assessment body is not excluded.

A sign of conformity^[2]



On steel for reinforcing concrete that complies with the requirements of this regulation, before its delivery to the market, a Serbian mark of conformity is placed in accordance with the regulation governing the method of conducting conformity assessment, the content of the certificate of conformity, as well as the form, appearance and content of the mark of conformity.

Safeguard Clause^[2]

The delivery or use of steel for concrete reinforcement that was delivered to the market of the Republic of Serbia and on which the mark of conformity is affixed, and which is found to not meet the requirements, may be limited or prohibited in accordance with the law regulating technical requirements for products and evaluation conformity.

Application of TQM and analysis of application of quality and safety of reinforcing steel^[3]

Quality is one of the key concerns of both small and large companies, which has the purpose of stability in the market.

Namely, mistakes, even on quality, can have a very far-reaching and devastating effect on the loss of users. First of all, you should examine the so-called waste points, that is, those places and activities that do not provide any value.

One of the important areas of marketing is sales, which actually represents a source of data for customers. This is done by focusing on and analyzing every point where value addition can be acted upon. In addition, the following elements can be checked or measured in particular:

1. Error rate in orders
2. User satisfaction with the sales process
3. Timeliness of delivery
4. Number of unanswered phone calls
5. Order size by negotiation
6. Profitability of individual sales

One of the big areas, especially important in a small business where problems usually arise, is finances. That is why TQM must be applied to improve financial processes and procedures. The ultimate goal is to identify and implement improvement.

Service companies can also introduce TQM, but there will be many difficulties with the process, quality indicators and improvements. The final result is customer satisfaction, which is the best proof of quality and recommendation to other customers.

For smaller businesses, improvements should include the following:

1. Economically produce products in small batches
2. Maintain small stocks of products and reproductive material
3. Apply new inventory management methods such as JIT (just in time)
4. Cooperate with users already during market research, development, production, and all the way to delivery



5. Carry out continuous improvement in cooperation with users

Small companies must introduce the composition of quality successively.

In particular, it is necessary to rely on a partnership with a larger company that already has an established level of quality. The second part is cooperation with professional staff, in order to constantly transfer experiences for the purpose of improvement.

In addition, it is possible to apply certain TQM packages in terms of quality improvement in small companies.

Example: Report on the performed quality control of reinforcing steel at the NN warehouse ^[4]

On the basis of the decision on the establishment of the Commission for Quality Control by the Legal Representative of Privredni drustva NN d.o.o., dated February 20, 2024. a three-member commission consisting of: Marko Marković, Nenad Nešković and **Bojana Miličić** performed the quality control of the material owned by Privredna društava NN d.o.o., which is located within the factory of the company SS for the processing of reinforcing steel.

Day 21.02.2024.

Start at 9 am.

Three-member commission: Marko Marković, Nenad Nešković, Bojana Miličić.

On the first day of control, a tour of the factory of the SS company was carried out.

The tour was for the purpose of planning and quality control strategy.

1. Overview of the machinery we plan to use

1.1. The parked truck was inspected

The inspection was carried out by a mechanic hired by the company NN.

It was found that in the middle of not using the vehicle for a long time (ignition and driving) the battery is empty and the mentioned vehicle cannot be started. It is necessary to hire separate trucks for transport, if the commission determines that the quality of the material is not compromised and if the sale is agreed upon.

1.2. It was established that the forklift, which is intended for us to help the commission for material manipulation, is also used during the day for the needs of the production plant.

1.3. The crane is faulty.

1.4. The scale is correct, checked in 2023, with a deviation of +/-20 kg. Figure 1.



Figure 1: Reading the measured weight of reinforcing steel



2. Inspection of the factory - space where the subject material is stored, plant

2.1. Molten cylindrical rod, ribbed, is in bundles, stored in piles, the quality of which can be assessed.

2.2. Melted rolled wire, smooth, is in bundles, stored in piles, the quality of which can be assessed.

2.3. The mesh reinforcement is in bundles, stored in piles, the quality of which can be assessed.

2.4. The plant was inspected and it was found that the fittings, which are in the production plant, are accessible to the commission, and its quality can be assessed. Figure 2.



Figure 2:Types of materials whole quality control

3. Analysis of the time required to assess the quality of the required material

By analyzing the collected information from the previous points, the commission established that the assessment of the quality of reinforcing steel can be accessed as early as tomorrow and that the material is available for analysis by the commission.

Day 21.02.2024.

Finishing at 3 pm.

Day 22.02.2024.

Start at 9 am.

By visiting the materials whose quality we are examining, it was established that it is necessary:

1. Production control. ^[9]

(Comparison with corresponding ISO standards.)

2. We will evaluate the atmospheric impact on each type of reinforcing steel.

(Materials were stored in an open area.)

3. We will ascertain whether the quality of the mentioned material affects the safety of the installation.

(In the case of reinforcing meshes, check the quality of the bar welds.)

4. Of course, it is necessary to take into account the answer to the last, but by no means less important question -

At the time of evaluation, did the quality affect the selling price?



(To ascertain whether such material was purchased after quality assessment in accordance with the market value of reinforcing steel)



Figure 3-Production facility

(production control from raw material to ribbed reinforcement; production control from raw material to reinforcing mesh;)

By visiting the plant, the commission established that the quality of production is satisfactory. Processed products meet all required ISO standards. Figure 3.



Figure 4-Product control, the quality of the finished products - reinforcing mesh and ribbed reinforcing bars - was checked on the spot.

In construction, reinforcing mesh has a very wide application.

Production, delivery and control of welded [7] reinforcing mesh is prescribed by the standard SRPS U.M1.091.

Quality control was also tested on cut beams (transverse and longitudinal) for tension according to the SRPS EN 10002-1 standard and bending SRPS C.A4.005, and testing of the load-bearing capacity of welded joints.

Care was taken, given that the material was stored outdoors during rainy days, whether the current corrosion affected the reduced quality of the aforementioned.

It was found to be secondary corrosion. The rate of corrosion ranges from 01-0.5 mm/year. Table 1. [1]

$$V_{\text{corr}} = \frac{m}{\rho \cdot s \cdot \tau} = \frac{M}{\rho \cdot z \cdot F} \cdot i_{\text{corr}} \cdot 8,76 \cdot 10^4 \text{ (mm/year)}$$

V_{corr} -corrosion rate (mm/year)

s-electrode surface (cm²)

m-mass of metal (g)

t-time (h)



ρ -densi of metal (7.85 g/cm^3)
reaction

z-the number of electrons exchanged in the

i_{corr} -corrosion current density (A/cm^2)^[5]

M-molar mass of metal ($55,8 \text{ g/mol}$)

F-Fradeeva const. ($26,8 \text{ Ah/mol}$)

Table 1:Corrosion resistance steel test

Sample name	Concentration $\text{Ca}(\text{OCl})_2$ (%)	I_{corr} ($\mu\text{A/cm}^2$)	Corosion rate (mm/year)	Measuring units of corrosion stability
Č 4572	50	12	0.139	5
	10	5,76	0,068	4
	1	1,10	0,0127	3
Č 4583	50	15,00	0,1742	6
	10	5,50	0,0644	5
	1	1,20	0,0139	4

Given that our material in question was stored in the open for only a few months, the commission concluded that the material is of satisfactory quality.



Figure 5-Rolling unprocessed steel wire

During the tour, the commission noticed that the unprocessed rolling wire was coated with blue protective paint - transport base paint.Figure 5.

The mentioned application ensures that the raw material is not damaged, and also has the function of protecting it from atmospheric influences.

Therefore, the commission concluded that the hot-rolled reinforcing steel in the bunts is of excellent quality.

The commission unanimously decided that the quality of the material that was in operation, both as raw material and as a finished product, is of excellent quality, following ISO standards, and is ready for installation. Storage in the open for a few months did not affect the quality market price.

The products were sold and transported to the customer on the same day.

When loading reinforcing steel into trucks for transport, the commission also paid great attention to product safety checks.^[8]



The reinforcing bars that are welded in the reinforcing meshes are welded with high quality.
The hot-rolled wire is properly bent into bundles.

Day 22.02.2024.

Finishing at 3 pm.

Conclusion

Successful quality management in construction is teamwork.

Teams participating in solving quality problems are made up of experts from 3 segments:

1. Experts who define quality and quality features (designers, instructors and technologists).
2. Experts who create quality (engineers, technicians and production workers from specialized subsystems).
3. Professionals who create foundations for quality management (quality engineers as designers).

The question of quality in the construction industry is very important, because it represents an important element of competitiveness in the market, which affects the decision to purchase a product. In the open world market, under conditions of free competition, there is a struggle to conquer the market by means of quality.

The market is not conquered by low prices, but by "high enough" quality that enables victory over the competition. Conquering the market segment by means of quality means safe and long-term placement of products and services, which is one of the basic elements of the company's survival. Of the three important market factors (quality, time and price), quality is today the most important market factor.

"If it is not possible to reject what is not good, it should at least be separated from what is good."⁵

(Dušan Radović)

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