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Quality costs in Bridge Engineering

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Summary

The current paper desires to create an introduction towards the research in quality costs for bridges.

The superior quality of bridges is a matter of great importance. The quality administration is determined by different instruments which are components of ISO 9000 standards. As for Romania the quality in the area of engineering is guided by the Law 10 of quality. The concept of quality costs has the main objective the identification, evaluation and comparison of costs. These costs administration must integrate all the phases of creation and exploitation of a bridge construction.

KEYWORDS: quality costs, bridges, Law 10 – quality law, design, execution and exploitation.

1. INTRODUCTION

The bridges network is ageing and so the agencies take more and more into consideration the maintenance and rehabilitation of the existent infrastructure.

The quality of bridge structures is influenced by different types of factors such as technical, economical, social and natural. Most of the times, their influence isn't an isolated phenomena but a simultaneous one. They interfere on the quality characteristics, creating the rise and fall of the quality general level.

Quality costs are the costs associated with preventing, finding, and correcting defective work. These costs may be huge. Many of these costs can be significantly reduced or completely avoided. One of the key functions of a Quality Engineer is the reduction of the quality total cost associated with a construction work.

2. GENERAL APPROACH OF TRANSPORTATION QUALITY COSTS

Considering the transport capacity already valuated, the agencies must focus more than before on the work zones effects on the users.

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The costs in a different approach can be connected to the transport infrastructure elements quality.

The most common is the traditional approach of the costs regarding the quality. It allows the determination of the source where they appear, the cause and quality costs measurement.

A certain time period the quality improvement and the quality costs reduction were considered differently. This problem was settled in 1979, in the paper „Quality is Free" by Ph. Crosby, where the quality costs are analyzed in detail. In its book, Crosby demonstrated the fact that the lack of quality determines complementary expenses. Even if in practice is difficult to identify and divide all the quality costs, an attempt in this direction brings into evidence looses due to the reparations, replacements, stagnation etc.

The determination of quality costs takes to profit increase by the identification of the most proper solutions of costs reduction.

Quality costs are grouped this way:

1. prevention
2. inspection
3. internal costs of unconformity
4. external costs of unconformity

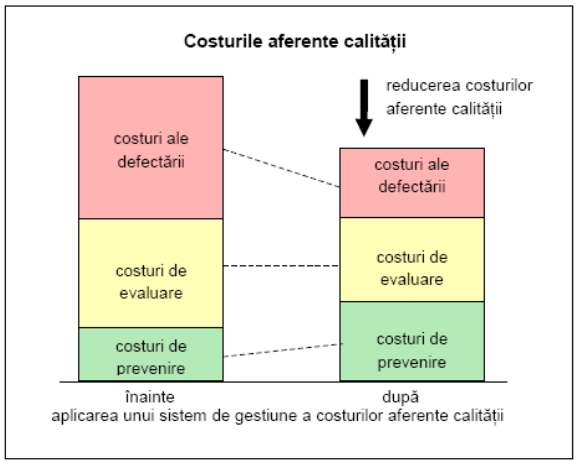

Fig. 1: Reduction of quality costs

Source: Marieta Olaru, "Costurile referitoare la calitate", in "Quality Management" Second Edition

Quality costs have different classifications as seen in Figure 1.

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The prevention costs in the area of bridges represent the investments done before the execution works or maintenance in order to prevent the defection in the next steps. Here are being included also the quality costs determined by the infrastructure impact on the environment. The lately transportation fast development had a great impact on the environment so that the transportation has become the main source of aggression on the environment and human health. The environment pollution due to a bridge structure takes place in two steps: the execution and exploitation.

Evaluation costs are inspection costs (testing, inspection, examinations) and tests which have been considered if the quality requests have been fulfilled. In the bridge area the evaluation costs represent the value of the effort done in order to determine the conformity degree of the construction works with the specified quality.

Internal unconformity costs in bridges execution and maintenance represents the costs of unconformity adjustments discovered after the works creation but before the element exploitation. These are expenditures caused by the fact that certain works quality level doesn't fulfill the specified requests.

External unconformity costs in the bridge area are the expenses determined by the unconformities correction discovered after the execution and maintenance works and after bringing into service the elements. These are costs caused by the fact that the quality level for certain constructions doesn't fulfill the specified requests.

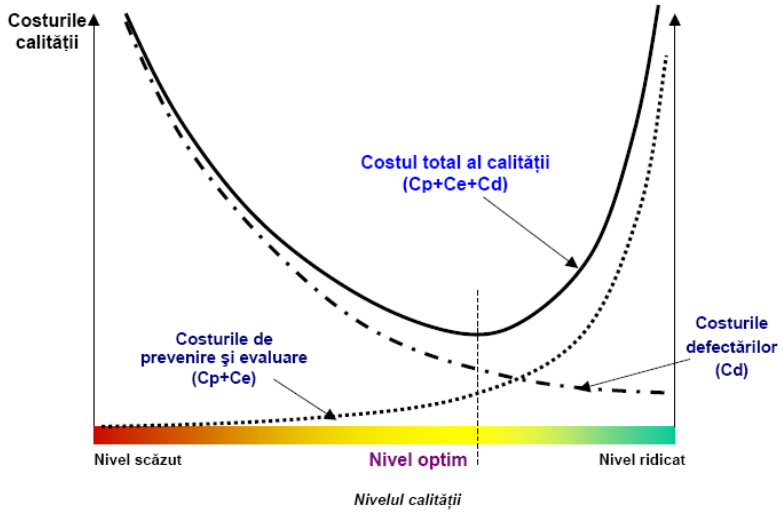

Fig 2 The connection between the quality and quality costs
Source: Marieta Olaru, "Costurile referitoare la calitate", in "Quality Management" Second Edition

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The connections between the quality costs categories is suggested in fig 2 by the graphical representation of the quality "optimal level". It can be seen that in the situation of a relatively small increase of the investments for the prevention and evaluation measures will result a sensitive reduction of the unconformity costs, so that, totally, the quality costs will decrease. This fact is also presented in the previous figure but with a different structure. On the other hand, in the case of neglecting the preventive quality costs component, can result important increases of the other expenses, considering the internal and external unconformity multiplication.

The decrease of any of the three expenses categories will lead towards the decrease of quality total cost, but the minimal level is in the equilibrium point between these three costs categories. As seen in figure, there is a point on the total expenses curve where these are minimal and this is a result of the combination between the unconformity costs and those of prevention and evaluation.

Being outside the optimal level means obtaining a low quality level, when the quality loses are greater than the investments, or obtaining a high level of quality, when unconformity costs reduction is done with great expenses for the prevention and evaluation and also by more important investments.

The quality costs are interconnected:

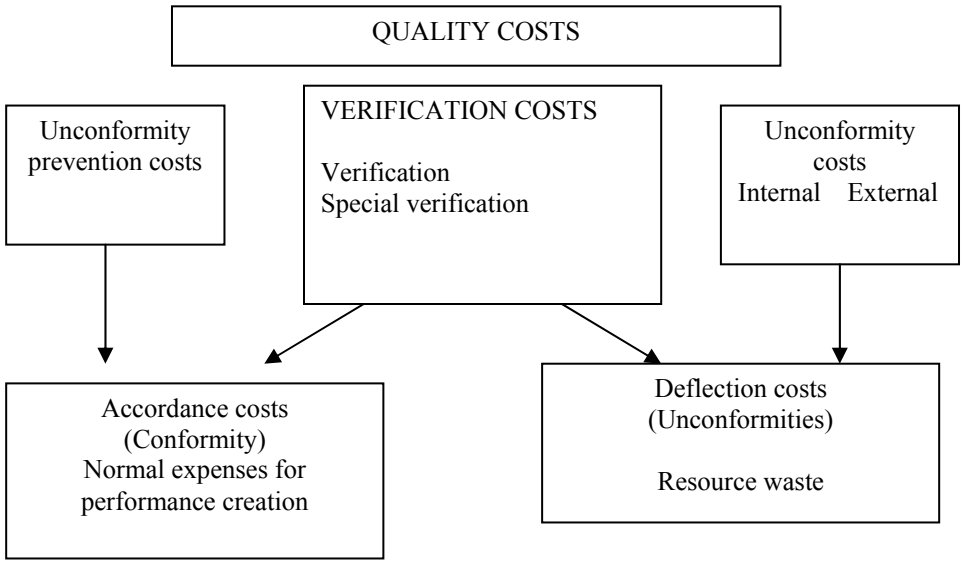

Fig 3 Quality costs

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Identification of the quality costs is necessary for operative and administrative procedures supervision. They are used as a strategic instrument to create projects and for measures argumentation.

Quality costs gathering and calculation is included into a quality management system. It is recommended a preventive treatment of the quality costs.

The basic point in quality costs treatment is represented by the unconformity prevention and costs, in the first steps of the construction and not the unconformities improvement.

A different vision on the quality costs starts from the Law 10 regarding the Quality in Constructions. For a bridge construction work are being taken into consideration as research points not only the quality regarding the bridge construction but also complementary elements such as:

- design
- execution
- exploitation

with the proper expenses for the quality.

If previously in general view, the accent is on the quality costs in the context of construction work exploitation, in the current view are being considered also the quality costs in the phase of design and execution.

3. QUALITY SYSTEM IN BRIDGE ENGINEERING

In accordance with Law no. 10 regarding the quality in construction, the quality system is composed from:

a. Technical regulation;
b. Quality of the products used for the construction creation;
c. Technical agreements for new products and technologies;
d. Projects verification, works execution and projects and constructions expertise;
e. Assurance of quality in construction area;
f. Authorization and accreditation of analysis laboratories and testing in construction activity;
g. Metrology activity in constructions;
h. Construction reception;
i. Behavior in exploitation and time intervention;
j. Construction post utilization;
k. State quality control in construction.

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In the area of Bridge Engineering, quality assurance, control and maintenance for a bridge has some particularities, specially, considering the exploitation period, the fact that this is designed, executed and exploited by different companies, by the long time contact with the environment and by its social importance.

This way, for every company must by developed and implemented a quality system with the purpose of realizing the quality policy objectives. In order to achieve the quality objectives are realized the mobilization of all the technical, administrative and human factors which can influence a construction quality. The quality system must be guided towards the reduction, elimination and most important prevention of qualitative deficiencies.

In order to implement the quality policies and deficiencies, in a company must be created proceedings regarding the personnel training, design activities coordination, bridge creation and maintenance.

Also, it is necessary to select all the activities which lead directly towards the assurance, administration and maintenance of the quality, reported to the design, creation and maintenance activities. Based on the specified data there must be determined as right as possible a bridge quality costs on the existence period.

4. AGENTS WHICH DETERMINE THE QUALITY IN BRIDGE ENGINEERING

Considering a critical analysis of the quality system components and the existence steps for a bridge such as: design, execution and exploitation can be determined the factors by which it can be assured the quality.

4.1. In the design phase, the factors which assure the bridge quality are:

a. The professional level of each member of the design collective (including the collective operational discipline);
b. The experience in the area of the design collective (the general experience and the specific experience for the design theme);
c. The informational system complexity (standardization, instructions, normative, treaty, similar projects etc.);
d. The used computer field system performance (data base, INTERNET, INTRANET, HARD, Soft);
e. The durability of the adopted constructive system (bridge on frames, girder bridge, etc.);
f. The site identification (information, technical and environmental knowledge, etc.);

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g. The capacity to satisfy the basic requests: resistance, stability, safety in exploitation, environment protection;
h. Optimization of the adopted constructive solution;
i. Project inspection, project expertise in the case of frictions between designer and verifier, approval of the internal technical department of the beneficiary.

4.2. Factors specific to the bridge construction phase:

a. Level of professional background of each and every member of the engineers collective (including the collective operational discipline);
b. Experience in the area of bridge execution and experience specific to the designed bridge type;
c. The complexity of used information system (standardization, instructions, technological methodologies etc.);
d. Performances of the analysis and testing laboratories;
e. Information related to the execution project acquired by the executor (relation between designer – executor);
f. Quality of the products used for the construction;
g. Bridge testing (if mentioned in the project);
h. Bridge reception.

4.3. In the exploitation phase the bridge quality maintenance factors are:

a. The level of professional background of each member of the experts collective in bridge maintenance, at beneficiary (including the collective operational discipline);
b. Experience in bridge exploitation area and experience specific to the received bridge type;
c. The bridge exploitation in accordance with the project specifications (weight, load class etc.);
d. Pursuit in exploitation of the received bridge behavior;
e. Processing and stocking of data and information from the determination in time of the bridge behavior;
f. Intervention in due time on the bridge: maintenance, repairing, consolidation etc.;
g. Construction expertise.

5. QUALITY COSTS IN BRIDGE ENGINEERING

Considering the factors specific for the creation of the bridge quality, the quality cost can be detailed in three main costs groups:

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a. The cost for quality assurance and damages prevention (constructive and technological, personnel training improvement, costs of the used equipments etc.);
b. Quality cost control (evaluation, remuneration, endowment etc.);
c. Costs of losses due to the non quality (remunerations, replaced elements, costs of intermissions in assembly delivering, looses in exploitation phase etc.).

Total cost of a bridge quality, C_{TC} is:

$$C_{TC} = C_{PA} + C_C + C_I + C_P$$

where:

C_{PA} - Prevention cost of the damages and assurance of the quality level;

C_C - Total quality control cost;

C_I - Maintenance costs at the beneficiary;

C_P - Looses due to the lack of quality.

6. CONCLUSIONS

In order to determine the quality costs it is necessary to study all the factors which influence the quality in a bridge life time, to detail these factors and to distinguish the quality costs considering the other activities costs which fulfill for the bridge edification.

At the bottom of quality costs evaluation we must consider the quality system correlated with the systems engineering concept by which the total creation of a bridge is determined by a system consisting from the design subsystem, creation (construction), exploitation and evaluation of the bridge.

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